KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

CURRICULUM GRADE 10 -12 DIRECTORATE

NCS (CAPS) SUPPORT

LAST PUSH REVISION LEARNER DOCUMENT

SOLUTIONS

PHYSICAL SCIENCES: PAPER 1 & 2

GRADE 12

2026

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VERTICAL PROJECTILE MOTION
SOLUTIONS
MULTIPLE CHOICE QUESTIONS

1.1 B ✓✓ (2)
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1.4 A ✓✓ (2)
1.5 C ✓✓ (2)
1.6 A ✓✓ (2)
1.7 B ✓✓ (2)

LONG QUESTIONS

QUESTION 2

2.1.1

OPTION 1 **UPWARD AS POSITIVE** **Ball A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= 12t + \frac{1}{2}(-9{,}8)t^2$ ✓................. (1) **Ball B** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $= -5{,}4(t-2) + \frac{1}{2}(-9{,}8)(t-2)^2$✓.... (2) $12t+\frac{1}{2}(-9{,}8)t^2 = -5{,}4(t-2)+\frac{1}{2}(-9{,}8)(t-2)^2$ $= -5{,}4(t-2) + \frac{1}{2}(-9{,}8)(t-2)^2$ ✓ $t = 4$ (s) ✓	**OPTION 1** **DOWNWARD AS POSITIVE** **Ball A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= -12t + \frac{1}{2}(9{,}8)t^2$ ✓........ (1) **Ball B** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $= 5{,}4(t-2) + \frac{1}{2}(9{,}8)(t-2)^2$ ✓.....(2) $-12t+\frac{1}{2}(9{,}8)t^2 = 5{,}4(t-2)+\frac{1}{2}(9{,}8)(t-2)^2$ ✓ $t = 4$ (s)✓

OPTION 2 **UPWARDS AS POSITIVE** $v_f = v_i + a\Delta t$ $12 = -12 + (9{,}8)\Delta t$ $\Delta t = 2{,}45$ s **Ball A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\Delta y=(12)(t-2{,}45)+\frac{1}{2}(9{,}8)(t-2{,}45)^2$..(1)✓ **Ball B** $\Delta y = (5{,}4)(t-2) + \frac{1}{2}(9{,}8)(t-2)^2$ ...(2)✓ $(12)(t-2{,}45)+\frac{1}{2}(9{,}8)(t-2{,}45)^2 = (5{,}4)(t-2) + \frac{1}{2}(9{,}8)(t-2)^2$ ✓ $t = 4$ s ✓	**OPTION 3** **UPWARDS AS POSITIVE** **Ball A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= 12(x+2) + \frac{1}{2}(-9{,}8)(x+2)^2$✓ $=(-4{,}9)x^2 - (7{,}6)x + (4{,}4)$ ....(1) **Ball B** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $= (-5{,}4)x + \frac{1}{2}(-9{,}8)x^2$ ✓ $= (-5{,}4)x + (-4{,}9)x^2$ .... (2) ✓ $(-4{,}9)x^2-(7{,}6)x+(4{,}4)=(-5{,}4)x+(-4{,}9)x^2$✓ $x = 2$ $t = 4$ s✓

(5)

2.1.2

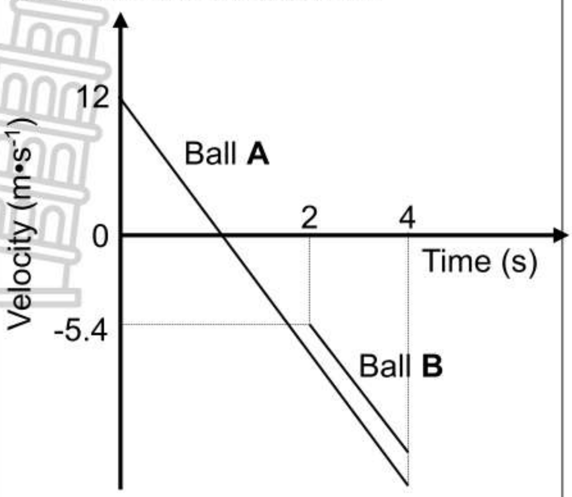
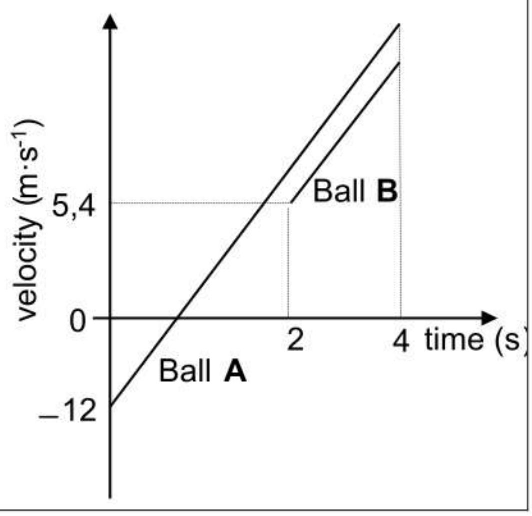
OPTION 1 **UPWARD AS POSITIVE** **Ball A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (12)(4) + \frac{1}{2}(-9,8)(4)^2$ ✓ $\Delta y = -30,4$ m Z = 30,4 (m) ✓	**OPTION 2** **UPWARD AS POSITIVE** **Ball B** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (-5,4)(4 - 2) + \frac{1}{2}(-9,8)(4 - 2)^2$ ✓ $\Delta y = -30,4$ m Z = 30,4 (m) ✓
OPTION 3 **UPWARDS AS POSITIVE** **Ball A** $v_f = v_i + a\Delta t$ $v_f = 12 + (-9,8)(4)$ $v_f = -27,2\ m\cdot s^{-1}$ $v^2_f = v^2_i + 2a\Delta y$ ✓ $(-27,2)^2 = (12)^2 + 2(-9,8)\Delta y$ ✓ $\Delta y = -30,4$ m Z = 30,4 (m) ✓	**OPTION 4** **UPWARDS AS POSITIVE** $v_f = v_i + a\Delta t$ $v_f = 12 + (-9,8)(4)$ $v_f = -27,2\ m\cdot s^{-1}$ $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{12 + (-27,2)}{2}\right)(4)$ ✓ $\Delta y = -30,4$ m Z = 30,4 (m) ✓

(3)

2.1.3

OPTION 1 **UPWARD AS POSITIVE** **Ball A** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(0)^2 = (12)^2 + 2(-9,8)(\Delta y)$ ✓ $\Delta y = 7,35$ m Y= 7,35+30.4 ✓ Y= 37,75 m ✓	**OPTION 1** **DOWN AS POSITIVE** **Ball B** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(0)^2 = (-12)^2 + 2(9,8)(\Delta y)$ ✓ $\Delta y = 7,35$ m Y= 7,35+30.4 ✓ Y= 37.75 m ✓
OPTION 2 **UPWARDS AS POSITIVE** **Ball A** $v_f = v_i + a\Delta t$ $0 = 12 + (-9,8)\Delta t$ $\Delta t = 1,22$ s $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= (12)(1,22) + \frac{1}{2}(-9,8)(1,22)^2$ ✓ $= 7,35$ m Y= 7,35+30,4 ✓ Y= 37,75 m ✓	**OPTION 3** **UPWARDS AS POSITIVE** **Ball A** $v_f = v_i + a\Delta t$ $0 = 12 + (-9,8)\Delta t$ $\Delta t = 1,22$ s $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{12 + 0}{2}\right)(1,22)$ ✓ $\Delta y = 7,32$ m Y= 7,35+30,4 ✓ Y= 37,75 m ✓

2.2 (4)

UPWARDS AS POSITIVE	DOWNWARDS AS POSITIVE
	

[16]

QUESTION 3

3.1 Motion in which the only force acting is gravitational force.✓✓ (2)

3.2.1

UPWARDS AS POSITIVE	DOWNWARDS AS POSITIVE
$v_f = v_i + a\Delta t$ ✓ $-6{,}87 = 20 + (-9{,}8)\Delta t$✓ $\Delta t = 2{,}74$ s ✓	$v_f = v_i + a\Delta t$ $6{,}87 = -20 + (9{,}8)\Delta t$✓ $\Delta t = 2{,}74$ s ✓

(3)

3.2.2

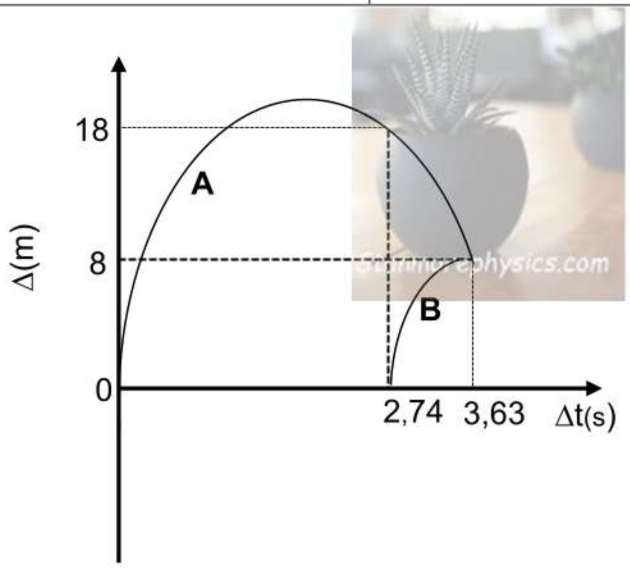
OPTION 1 **UPWARD AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(-6.87)^2 = (20)^2 + 2(-9{,}8)(\Delta y)$ ✓ $\Delta y = 18$ m✓	**OPTION 1** **DOWN AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $(6.8)^2 = (-20)^2 + 2(9{,}8)(\Delta y)$ ✓ $\Delta y = 18$ m ✓
OPTION 2 **UPWARD AS POSITIVE** $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{20 + (-6.87)}{2}\right)(2{,}74)$✓ $\Delta y = 17.99$ m ✓	**OPTION 3** **UPWARDS AS POSITIVE** $\Delta y = v_i\Delta t + ½a\Delta t^2$✓ $= (20)(2.74) + ½(-9{,}8)(2.74)^2$✓ $\Delta y = 18.01$ m✓

(3)

3.3

POSITIVE MARKING FROM QUESTIONS 3.2.1 & 3.2.2 **UPWARDS AS POSITIVE** **Ball A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\underline{8 = 20\Delta t + \frac{1}{2}(-9,8)\Delta t^2}$ ✓ $\Delta t = 3,63$ s or 0.45 s Ball A took 3,63 s to reach point Q **Ball B** **Time taken ball b to reach point Q** $\underline{3,63-2,74}$ ✓=0,89 $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $\underline{8 = v_i(0,89) + \frac{1}{2}(-9,8)(0.89)}$ ✓ $v_f = 13,35\ m\cdot s^{-1}$ ✓	**OPTION 2** **UPWARDS AS POSITIVE** **Ball A** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $\underline{8-17,99 = -6,87\Delta t + \frac{1}{2}(-9,8)\Delta t^2}$ ✓ $\Delta t = 0,89$ s or -2,29 s $\Delta t = 0,89$ s **Ball B** $\therefore \Delta t(\mathbf{A}) = \Delta t(\mathbf{B}) = 0,89$ s $\Delta t = 0,89$ s $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ 8 ✓$= v_i(0,89) + \frac{1}{2}(-9,8)(0.89)$ ✓ $v_f = 13,35\ m\cdot s^{-1}$ ✓	

3.4



(5)
[18]

QUESTION 4

4.1 An <u>object</u> which has been given an <u>initial velocity</u> and then moves under the influence of <u>gravitational force only</u>. ✓✓ (2)

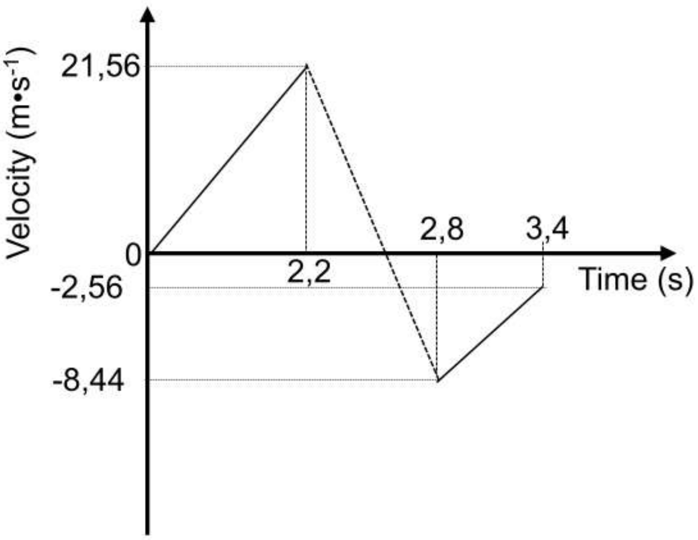
4.2 From:

- 0–2,2 s: Object falls from rest with constant acceleration of 9,8 $m\cdot s^{-2}$ downwards. ✓
- 2,2–2,8 s: Object is in contact with the ground experience an acceleration of 50 $m\cdot s^{-2}$ upwards✓ (3)

- 2,8–3,4 s: Object is moves upward at a constant acceleration of 9,8 $m\cdot s^{-2}$ downwards✓

4.3.1	**UPWARDS AS POSITIVE** $v_f = v_i + a\Delta t$ ✓ v_f=0+(-9,8)(2,2)✓ v_f = 21,56 $m\cdot s^{-1}$ downward ✓ OR Area=lb✓ v_f =(-9,8)(2,2)✓ v_f =21,56 $m\cdot s^{-1}$ downward✓	**DOWNWARDS AS POSITIVE** $v_f = v_i + a\Delta t$ ✓ v_f=0+(9,8)(2,2)✓ v_f = 21,56 $m\cdot s^{-1}$ downward ✓ OR Area=lb✓ v_f =(9,8)(2,2) ✓ v_f =21,56 $m\cdot s^{-1}$ downward✓	(3)
4.3.2	**OPTION 1** **UPWARDS AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ $= (0)(2,2) + \frac{1}{2}(-9,8)(2,2)^2$ ✓ = 23,72 m ✓	**OPTION 1** **DOWNWARDS AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ $= (0)(2,2) + \frac{1}{2}(9,8)(2,2)^2$ ✓ = 23,72 m ✓	
	OPTION 2 **POSITIVE MARKING FROM Q 4.3.1** $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{0 +(- 21,25)}{2}\right)(2,04)$✓ Δy = 23,716 m h= 23,72 m✓	**OPTION 4** **POSITIVE MARKING FROM Q 4.3.1** $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ $\Delta y = \left(\frac{0 +21,25}{2}\right)(2,04)$✓ Δy = 23,716 m h= 23,72 m✓	(3)
4.3.3	**POSITIVE MARKING FROM Q 4.3.1** **UPWARDS AS POSITIVE** $v_f = v_i + a\Delta t$ v_f=-21,56✓+(50)(0.6)✓ v_f = 8,44 $v_f = v_i + a\Delta t$ ✓ v_f=8,44+(-9.8)(0.6)✓ v_f = 2,56 $m\cdot s^{-1}$ downward ✓	**POSITIVE MARKING FROM Q 4.3.1** **DOWNWARDS AS POSITIVE** $v_f = v_i + a\Delta t$ v_f=21,56✓+(-50)(2,2)✓ v_f = 8.44 $v_f = v_i + a\Delta t$ ✓ v_f=-8,44+(9.8)(0.6)✓ v_f = 2,56 $m\cdot s^{-1}$ downward ✓	(5)

4.4



(5)

[21]

QUESTION 5

5.1 Motion in which the only force acting is gravitational force.✓✓ (2)

5.2.1 P (1)

5.2.2 Q (1)

5.3 0 ($m \cdot s^{-1}$✓) (1)

5.4.1

OPTION 1 **UPWARD AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓ 100 ✓$= 0\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$✓ $\Delta t = 4{,}52$ s✓	**OPTION 1** **DOWN AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ -100 ✓$= 0\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$✓ $\Delta t = 4{,}52$ s✓
OPTION 2 **UPWARDS AS POSITIVE** **Ball A** $v_f^2 = v_i^2 + 2a\Delta y$ $v^2 = (0)^2 + 2(-9{,}8)(-100)$ $V_f = 44{,}27 m \cdot s^{-1}$ $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ -100✓ $= \left(\frac{0 + (-44{,}27)}{2}\right)(\Delta t)$✓ $\Delta t = 4.52$ s ✓	**OPTION 4** **DOWN AS POSITIVE** **Ball A** $v_f^2 = v_i^2 + 2a\Delta y$ $v^2 = (0)^2 + 2(9{,}8)(100)$ $V_f = 44{,}27 m \cdot s^{-1}$ $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$ ✓ 100✓ $= \left(\frac{0 + (44{,}27)}{2}\right)(\Delta t)$✓ $\Delta t = 4.52$ s ✓

(4)

5.4.2 **POSITIVE MARKING FROM 5.3 & 5.4.1**

OPTION 2 **DOWN AS POSITIVE** $v_f^2 = v_i^2 + 2a\Delta y$ ✓ $v^2 = (0)^2 + 2(9{,}8)(100)$ ✓ $v_f = 44{,}27 m \cdot s^{-1}$✓	**OPTION 4** **DOWN AS POSITIVE** $v_f = v_i + a\Delta t$ ✓ $v_f = 0 + (9{,}8)(4{,}52)$ ✓ $v_f = 44{,}27 m \cdot s^{-1}$✓

(3)

5.5

OPTION 2 **UPWARDS AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $\Delta y = (0)(3) + \frac{1}{2}(-9{,}8)(3)^2$ ✓ $\Delta y = 44{,}1$ m Height$_{(\text{hot air balloon})} = 62–44{,}1$ ✓$= 18$ m $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓(or $\Delta y = v_i\Delta t$) $18 = (v_i)(3) + \frac{1}{2}(0)(3)^2$ ✓ $V_f = 6 m \cdot s^{-1}$ upwards✓	**OPTION 3** **DOWN AS POSITIVE** $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $\Delta y = (0)(3) + \frac{1}{2}(9{,}8)(3)^2$ ✓ $\Delta y = 44{,}1$ m Height$_{(\text{hot air balloon})} = 62–44{,}1$ ✓$= 18$ m $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$✓(or $\Delta y = v_i\Delta t$) $-18 = (v_i)(3) + \frac{1}{2}(0)(3)^2$ ✓ $V_f = 6 m \cdot s^{-1}$ upwards✓

(5)

[17]

QUESTION 6

6.1 An object which has been given an initial velocity and then it moves under the influence of the gravitational force only. ✓✓ (2)

6.2 Distance = area under graph OR ½bh ✓

= ½ x 0,8✓ x 7,84✓

= 3,14 m ✓ (4)

6.3 0,2 seconds ✓ (1)

6.4

$$F_{net} = \frac{\Delta p}{\Delta t}$$

$$F_{net} = \frac{m\Delta v}{\Delta t} \checkmark$$

$$F_{net} = \frac{0{,}175(1{,}53 - 7{,}84)\checkmark}{0{,}2\checkmark}$$

= - 5,52 N

= 5,52 N upwards ✓ (4)

6.5 $v_f = v_i + a\Delta t$ ✓

= 1,53 + (9,8)(0,7) ✓

= 8,39 m·s^{-1} ✓

$$a = \frac{y_2 - y_1}{x_2 - x_1} \checkmark$$

$$9{,}8 = \frac{v_f - 1{,}53}{1{,}7 - 1} \checkmark$$

v_f = 8,39 m·s^{-1} ✓ (3)

6.6 Equal to ✓ (1)

[15]

QUESTION 7

7.1 Weight / Gravitational force ✓ (1)

7.2.1 t = 0,67 – 0,64 ✓

= 0,03 s ✓ (2)

7.2.2

$$t = \frac{1{,}9 - 0{,}67}{2} \checkmark$$

= 0,62 s ✓ (2)

7.2.3 $v_f = v_i + a\Delta t$ ✓

0 = v_i + (-9,8)(0,62) ✓

v_i = 6,08 m.s^{-1} ✓ (3)

7.2.4 $v_f^2 = v_i^2 + 2a\Delta y$ ✓

$(0)^2 = v_i^2 + 2(-9{,}8)(1{,}2)$ ✓

v_i = 4,85 m.s^{-1}

$\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓

$1{,}2 = 4{,}85\Delta t + \frac{1}{2}(-9{,}8)\Delta t^2$ ✓

$\Delta t = 0{,}49$ s

$t = 1{,}97 + 2 \times 0{,}49$ ✓

$= 2{,}95$ s ✓ (6)

[14]

WORK, ENERGY & POWER

SOLUTIONS
QUESTION 1

1.1 B ✓✓ (2)

1.2 C ✓✓ (2)

1.3 A ✓✓ (2)

1.4 B ✓✓ (2)

1.5 A ✓✓ (2)

[10]

QUESTION 2

2.1 The net/total work done (on an object) is equal to the change in the object's kinetic energy. (2)

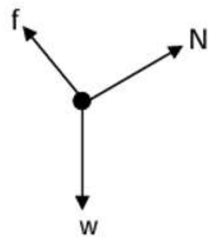
2.2 $W_{net} = \Delta E_k$ ✓

$F_A\Delta x\cos\theta = ½ mv_f^2 - ½ mv_i^2$

$(12)(7)\cos 0° = E_{kf} – 0$ ✓

$E_{kf} = 84$ J ✓ (3)

2.3



(3)

Mark awarded for label and arrow.

2.4 $W_{net} = \Delta Ek$

$W_{Fg} + W_{fk} = E_{kf} - E_{ki}$

$F_{g//}\Delta x\cos\theta + f_k\,\Delta x\cos\theta = E_{kf} - E_{ki}$

$mg\sin\theta\Delta x\cos\theta + f_k\Delta x\cos\theta = E_{kf} - E_{ki}$

$(3)(9,8)\sin20°\Delta x\cos0°$ ✓ $+ 21\Delta x\cos180°$ ✓ $= 0 - 84$ ✓

$\Delta x = 7,68$ m ✓

7,68 m > 6,8 m

The crate will pass point C. ✓ (5)

[13]

QUESTION 3

3.1 Backwards/behind him✓ (1)

3.2 Newton's third Law of ✓motion

When one body exerts a force on a second body, the second body exerts a force of equal magnitude ✓ in the opposite direction on the first body. ✓ (3)

3.3 $W_{net} = \Delta K$ ✓

$W_g + W_f = \Delta K$

$Fg\Delta x\cos\theta + f\Delta x\cos\theta = \Delta K$

$(57)(9,8)(4)\cos180°$ ✓ $+ 40\Delta x\cos180°$ ✓ $= 0 - ½\,(57)(6^2)$ ✓

$\Delta x = -\ 30,21$ m

$\text{Sin}\ \theta = \frac{4}{30.21}$

$\theta = 7,61°$ ✓ (5)

3.4 $W_{net} = \Delta K$ ✓

$W_T + W_g + W_f = \Delta K$

$(80)(5)(4)\cos0°$ ✓ $+(15)(5)\cos180°$ ✓ $=$

$(4)(9,8)\sin30°(5) - (4)(9,8)(0)$ ✓ $+ ½\,(4)v_f^2 - ½\,(4)(3)^2$ ✓

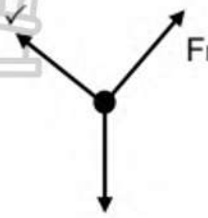
$v_f = 11,07\ m\cdot s^{-1}$ ✓ (6)

[15]

QUESTION 4

4.1 The net work done on an object by a force is equal to the change in the object's kinetic energy. ✓✓ (2)

4.2



Accepted labels	
Fg ✓	W/Fw/weight/mg / gravitational force
F_f ✓	(Kinetic) friction / f/fk
F_N ✓	Fnormal/Normal/N

(3)

4.3 $W_{net} = (W_{Fnormal}) + W_{friction} + W_{Fgravity}$ ✓

$W_{net} = (0) + \mu_k N.\Delta x.\cos\theta + mg.\Delta x.\cos\theta$

$W_{net} = 0 + (0{,}42)(850)(9{,}8)(\cos 30°)$✓$(200)(\cos 180°)$✓$(850)(9{,}8)(200)(\cos 60°)$✓

$W_{net} = (-\ 605\ 975{,}2955) + 833\ 000$

$W_{net} = 227\ 024{,}\ 7045$ (or $227\ 024{,}\ 7$) J ✓

(5)

4.4 $\Delta E_{K\ \text{from B to C}} = E_{Kf} - E_{Ki}$

$-\ 108\ 950 = E_{Kf} - 227\ 024{,}\ 7045$ ✓

$E_{Kf\ \text{at C}} = 118\ 074{,}\ 7045$

$W_{net} = \Delta E_K$ ✓

$W_{Fnormal} + W_{Fgravity} + W_{friction} + W_{Fbrakes} = \Delta E_K$

$0 + 0 + \mu_k N.\Delta x.\cos\theta + F_{brakes}.\Delta x.\cos\theta = E_{Kf\ \text{at D}} - E_{Ki\ \text{at C}}$

$0 + 0 + (0{,}42)(850)(9.8)$✓$(50)(\cos 180°)$✓$+ F_{brakes}.(50)(\cos 180°)$ ✓$= 0 - 118\ 074{,}\ 7045$ ✓

$F_{brakes} = -\ 1137{,}106$ N

magnitude of $F_{brakes} = 1137{,}106$ N ✓ (7)

[17]

QUESTION 5

5.1 $\Delta U + \Delta K = 0$ ✓

$(5)(9{,}8)(5) + 0$✓ $+ (0 + ½(5v_f^2))$ ✓ $g = 0$

$v_f = 2\sqrt{\ \times 9{,}8 \times 5}$

$= 9{,}90\ m{\cdot}s^{-1}$✓ $(9{,}899\ m{\cdot}s^{-1})$ (4) (4)

5.2 $W_{nc} = \Delta U + \Delta K$ ✓ $F\,\Delta x \cos\theta = \Delta U + \Delta K$

$(18\,\Delta x \cos 180$✓$) = (5)(9{,}8)(3 - 0)$ ✓ $+ ½(5)(0 - 9{,}90^2)$✓

$\Delta x = 5{,}4458 m$✓

$\theta = \sin^{-1}$ ✓$\frac{3}{5.4458}$

$\theta = 33{,}43^o$ ✓ (7)

[11]

QUESTION 6

6.1.1 A system on which the net external force is zero. ✓✓ (2)

6.1.2 $(U + K)_A = (U + K)_B$✓

$mgh + ½mv^2 = mgh + ½mv^2$

$gh + ½(v_i)^2 = gh + ½v_f^2$

$(9{,}8)(0{,}67) + ½(0)^2$ ✓ $= 0 + ½v_f^2$ ✓

$v_f = 3{,}6238\ m{\cdot}s^{-1}$

$m_b v_{is} + m_c v_{ic} = m_b v_{fs} + m_c v_{fc}$ ✓

$5(3.6238) + 0$ ✓ $= 5v_{fs} + 2(4.95)$ ✓

$V_{fs} = 1.6438\ m{\cdot}s^{-1}$ ✓ (7)

6.1.3 $(U + K)_{before} = (U + K)_{after}$✓

$mgh + ½mv^2 = mgh + ½mv^2$

0✓ $+ ½(5)(1{,}6438)^2$ ✓ $= (5)(9{,}8)h + 0$ ✓

$h = 0{,}138$ m ✓ (5)

6.1.4 Some of the ball's mechanical energy is transferred to the block. ✓ ✓ (2)

6.2.1 The net/total work done on an object is equal to the change in the object's kinetic energy. ✓ ✓ (2)

6.2.2 $W_{nc} = \Delta EK + \Delta U$ ✓

$W_{nc} = \Delta E_K + \Delta E_P$

$W_f = ½(2)(2^2 - 4{,}95^2)$ ✓ $+ (2)(9{,}8)(0{,}5 - 0)$ ✓ (4)

$= -10{,}7 \text{ J}$ ✓

[22]

QUESTION 7

7.1 A force is non-conservative if the work it does/done on an object which is moving between two points depends on the path taken. ✓ ✓ (2)

7.2 $W_{net} = \Delta K$ ✓

$mg\sin\theta\Delta x\cos\theta + W_f + W_F = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$(20)(9{,}8)(\sin 18^{\circ})(15{,}6)\cos 180^{\circ}$ ✓ $+ (13{,}5)(15{,}6)\cos 180^{\circ}) + (96{,}8)(15{,}6)\cos 0^{\circ}$ ✓ $=$
$\frac{1}{2}(20)(v_f^2 - 0)^2$ ✓

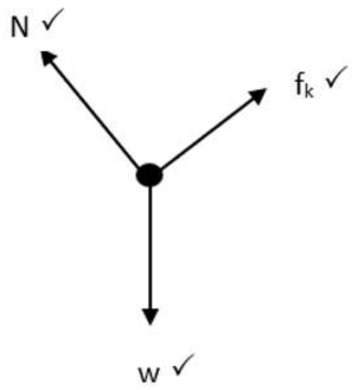
$v_f = 5{,}96 \text{ m·s}^{-1}$ ✓ (5)

7.3 $P_{ave} = Fv_{ave}$ ✓

$= 96{,}8\left(\frac{(0)+(5{,}96)}{2}\right)$ ✓

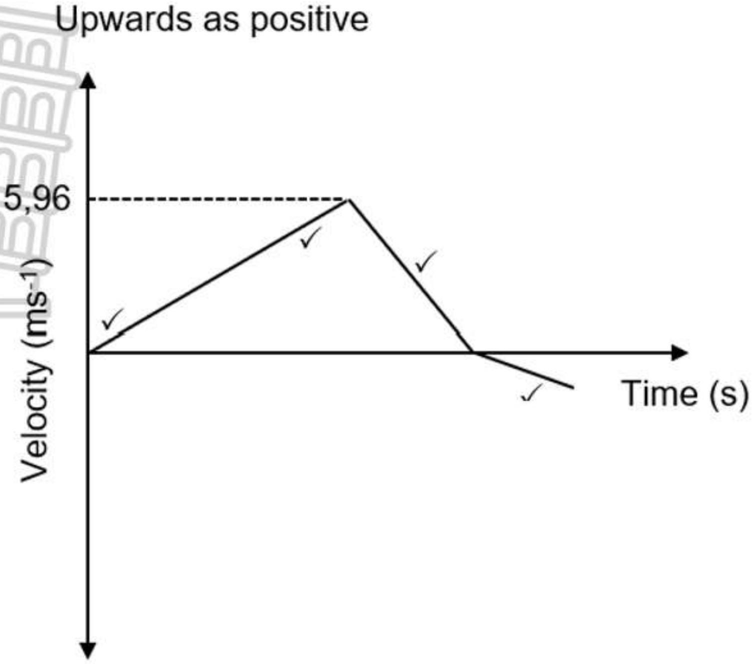
$= 288{,}46 \text{ W}$ ✓ (3)

7.4



(3)

7.5 (4)

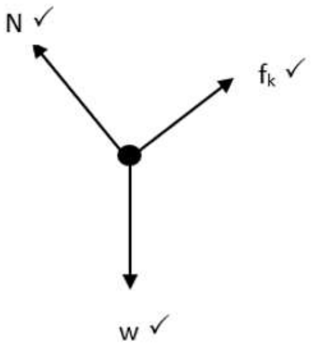


[17]

QUESTION 8

8.1 A force for which the work done in moving an object between two points depends on the path taken. ✓ ✓ (2)

8.2



(3)

8.3 The net workdone on an object is equal to the change in the object's kinetic enegy. ✓ ✓ (2)

8.4.1 $W_{nc} = \Delta E_K + \Delta E_P$ ✓

$W_f = \Delta E_K + \Delta E_P$

$W_f = ½\, mv_f^2 - ½\, mv_i^2 + mgh_2 - mgh_1$

$2,5 \times \frac{5}{\sin 10} \cos 180^o$ ✓ $= ½ \times 2 \times v_f^2 - 1,5^2$ ✓ $+ 2 \times 9,8 \times 0 - 2 \times 9,8 \times 5$ ✓

$v_f = 5,32\ m{\cdot}s^{-1}$ ✓ (5)

8.4.2 $f_k = \mu_k N$

$2{,}5 = \mu k \times 2 \times 9{,}8\cos 10^o$

$\mu k = 0{,}13$

$W_f = \Delta E_k + \Delta E_p$

$W_f =\ W_f = ½\ mv_f^2 - ½\ mv_i^2 + mgh_2 - mgh_1$

$0{,}13\ (2 \times 9{,}8) \times \cos 180^o$ ✓ $= ½ \times 2 \times 0^2\ ½ \times 2 \times 5{,}32^2$ ✓ $+ 0$

$\Delta x = 11{,}11$ m ✓ (5)

[17]

QUESTION 9

9.1 A force for which the work done in moving an object between two points depends on the path taken. (2)

9.2 $W_{net} = \Delta K$✓

$W_{motor} + W_w + W_f = ½\ m(v_f^2 - v_i^2)$

$W_{motor} + (60)(9{,}8)(30)\cos 115^o$✓$+ (16{,}2)(30)\cos 180^o$✓$= ½\ (60)(7{,}5^2 - 0^2)$ ✓

$W_{motor} = 9628{,}486J$

$P = \frac{W}{\Delta t}$ ✓

$P = \frac{9628{,}486}{120}$ ✓

$P = 80.24W$ ✓

(7)

9.3 DECREASES ✓

• ΔK stays the same✓

• Work done by the motor is in the same direction as work done by the gravitational force ✓ (3)

[12]

ELECTRODYNAMICS
SOLUTIONS
MULTIPLE CHOICE

1.1 C✓✓
1.2 A✓✓
1.3 C✓✓
1.4 B✓✓

[8]

STRUCTURED QUESTIONS
QUESTION 2

2.1 The AC potential difference /voltage that produces/dissipates the same amount of energy as an equivalent DC potential difference/voltage. ✓✓ (2)

2.2 N/North✓✓ (2)

2.3

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓

$= \frac{311.11}{\sqrt{2}}$

$= 219{,}99\ V$

$P_{ave} = \frac{V^2_{rms}}{R}$ ✓

$= \frac{219{,}99^2}{60}$ ✓

$= 806{,}59\ W$

$= 0{,}80659\ KW$

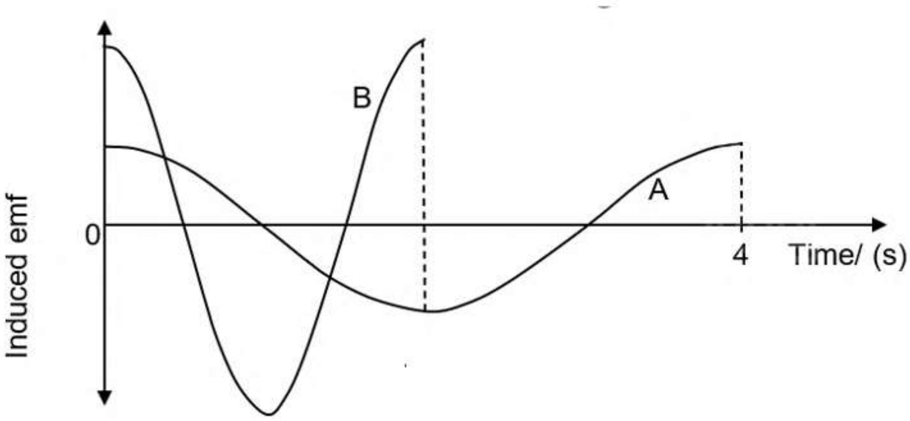
cost = PΔt × tariff

= 0.80659 (1.5)(3.33) ✓

= R 4.03✓

(5)

2.4



Amplitude of graph B is bigger than that of graph A✓
Period of B is half of A✓

Correct shape and one Cycle✓

2.5 By replacing slip rings with split ring commutator / split ring / commutator. ✓ (1)

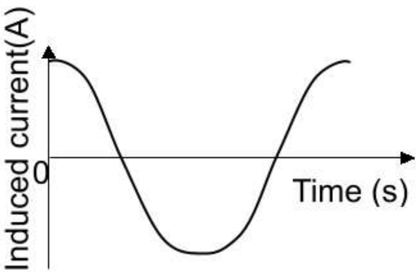
[13]

QUESTION 3

3.1.1 North✓✓ (2)

3.1.2
- Increase speed of the rotation✓
- Increase number of coils (turns)
- Use magnet with stronger field/stronger magnet/increase magnetic flux/electromagnets/ insert soft iron core (1)

3.1.3



(3)

3.2.1 Root-mean- square current is the alternating current (AC) that dissipates the same amount of energy/heating effect as an equivalent direct current (DC) ✓✓

(2)

3.2.2

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓

$= \frac{340}{\sqrt{2}}$

$= 240,42$ V

$P_{ave} = I_{rms}V_{rms}$ ✓

$1200 = (240,42)\ I_{rms}$ ✓

$I_{rms} = 4,99$ A ✓

(4)

3.2.3

$P_{ave} = \frac{V^2_{rms}}{R}$ ✓

$1200 = \frac{240,42^2}{R}$ ✓

$R = 48,17\ \Omega$ ✓

(3)

[15]

QUESTION 4

4.1 Split ring (commutator) Accept: Commutator✓ (1)

4.2 Anticlockwise✓✓ (2)

4.3 Electrical to mechanical✓ (1)

4.4.1 (3)

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓

$= \frac{311}{\sqrt{2}}$ ✓

$= 220$ V✓

4.4.2

$P_{ave} = \frac{V^2_{rms}}{R}$

$= \frac{220^2}{30}$ ✓

$= 1\ 613,\ 33$ W

$P_{ave} = I_{rms}V_{rms}$ ✓

$1\ 613,\ 33 = I_{rms}(220)$ ✓

$I_{rms} = 7,33$ A✓

(4)

[11]

QUESTION 5

5.1.1 (split-ring) Commutator✓✓ (2)

5.1.2 A – South✓
B – North✓ (2)

5.2.1 The rms current is the alternating current that dissipates/produces the same amount of energy as the equivalent direct current (DC). ✓ ✓ (2 or zero) (2)

5.2.2

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓

$= \frac{10.6}{\sqrt{2}}$ ✓

$= 7.495$ A✓ (3)

5.2.3

$Pmax = VmaxImax$ ✓

$= (300)\ (10,6)$

$= 3180$ W ✓

$P_{ave} = \frac{3180}{2}$

$= 1590$ W✓

(3)

5.2.4 Maximum✓ (1)

5.2.5 AC can be transported over long distances as it can be transformed (Step up/ down) to minimise power loss. ✓✓
It is easier to generate AC current.
OR Higher voltage means lower current $P \alpha I^2$. (2)

[15]

QUESTION 6

6.1 The rms voltage of AC is the AC potential difference which dissipates produces the same amount of energy as an equivalent DC potential difference. ✓✓ (2)

6.2 Mechanical energy to electrical energy. ✓ (1)

6.3 It can be stepped up or stepped down/is easier to transmit P with less energy lost

AC can be converted to DC but DC cannot be converted to AC ✓ (1)

6.4

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓

$= \frac{311}{\sqrt{2}}$ ✓

$= 220\ V$

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$

$= \frac{21}{\sqrt{2}}$ ✓

$= 4{,}85\ A$

Pave = VrmsIrms ✓

= (219,91) (14,85) ✓

= 3265,66 W ✓

(6)

[10]

QUESTION 7

7.1 AC ✓ as there are sliprings ✓ (2)

7.2 Mechanical energy to electrical energy ✓ (1)

7.3 a to b ✓ (1)

7.4

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$

$I_{max} = (4{,}55)(\sqrt{2})$ ✓

$= 6{,}434\ A$

$R = \frac{V_{max}}{I_{max}}$ ✓

$= \frac{150}{6{,}434}$ ✓

$= 23{,}31\ \Omega$ ✓

(4)

7.5

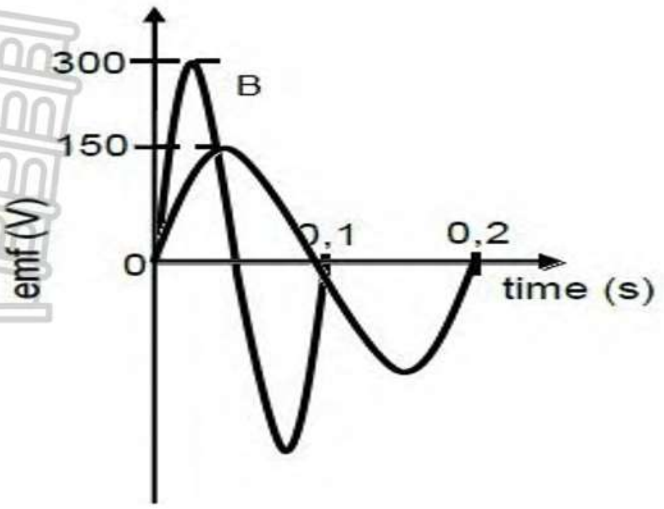
$W = P\Delta t$ ✓

$= (400)(3 \times 60)$ ✓

$= 72\ 000\ J$ ✓

(3)

7.6.1



double the emf/amplitude/300 ✓

half the frequency ✓

(2)

7.6.2 With a factor 4W ✓

ε α1/Δt ✓if N and flux stay constant.

If the rotation doubles, the induced emf will double ✓

W α V^2 if R and Δt stay constant ✓
and energy emitted will quadruple (4x)

(4)

[17]

ELECTROCHEMISTRY
SOLUTIONS
GALVANIC CELLS
QUESTION 1

1.1	C ✓✓	(2)
1.2	A ✓✓	(2)
1.3	A ✓✓	(2)
1.4	D ✓✓	(2)
1.5	B ✓✓	(2)
		[10]

QUESTION 2

2.1 Pressure: 101, 3kPa (1 atm) ✓
Temperature: 25°C ✓ (2)

2.2 Salt bridge ✓ (1)
2.3 Anode. ✓
Mg is a stronger reducing agent✓ than H_2 ✓, and Mg will be oxidised. ✓ (4)
2.4 ✓ ✓ ✓
$Mg(s) \mid Mg^{2+}(aq) \parallel H^{+}(aq) \mid H_2(g) \mid Pt(s)$ (3)
2.5 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ ✓
2, 36 ✓= 0.00 – (E^{θ}_{anode}) ✓
= -2, 36 V ✓ (4)
2.6 $Mg(s) + 2H^{+}(aq)$ ✓ → $Mg^{2+}(aq) + H_2(g)$ ✓ Bal. ✓ (3)
[17]

QUESTION 3
3.1 A solution✓ that conducts electricity through the movement of ions. ✓ (2)
3.2 $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$ ✓✓ (2)
3.3.1 Temperature of 25 ºC/298K ✓
Concentration of the electrolytes equals 1 $mol.dm^{-3}$. ✓ (2)
3.3.2 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ ✓; 0, 63 ✓= 0.00 – (- 0,76) ✓
= - 0, 13 V ✓; Therefore, **X** is Lead ✓ (5)
3.4 ✓ ✓ ✓
$Zn(s) \mid Zn^{2+}(aq) \parallel Pb^{2+}(aq) \mid Pb(s)$ (3)
3.5 0 (V) ✓ (1)
[15]

QUESTION 4
4.1 Concentration: 1 $mol{\cdot}dm^{-3}$ ✓; Temperature: 25 °C ✓ (2)
4.2 To ensure electrical neutrality. ✓ and to separate the two electrolytes. ✓ (2)
4.3 Ni to Ag ✓ (1)
4.4 $Ni(s) + 2Ag^{+}(aq)$ ✓→ $Ni^{2+}(aq) + 2Ag(s)$ ✓ balancing ✓ (3)
4.5 n(anode) = ½ n(cathode) = ½ (0,4) = 0,2 mol. ✓
m = n.M = 0, 2 x 59 ✓= 11,8 g ✓ (3)
4.6 B ✓
Mg ✓ is a stronger reducing agent than Ni.✓ Mg will be oxidized to Mg^{2+}✓ (4)
[15]

QUESTION 5
5.1 A solution✓ that conducts electricity through the movement of ions. ✓ (2)
5.2 ✓ ✓ ✓
$Pb(s) \mid Pb^{2+}(aq) \parallel Ag^{+}(aq) \mid Ag(s)$ (3)
5.3 Potassium Chloride (KCl) ✓ (2)
5.4 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ ✓ = 0.80 ✓– (- 0,13) ✓ = 0, 93 V ✓ (4)

QUESTION 6
6.1.1 Zinc (Zn) ✓ (1)
6.1.2 Mn^{-}_{4} is a stronger oxidising agent✓ than Zn^{2+} ions✓ and will oxidise Zn ✓ (3)
6.2.1 To ensure electrical neutrality. ✓
To separate the two electrolytes. ✓ (2)
6.2.2 Mn to Ni (2)
6.2.3 $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ ✓ = - 0.27 ✓– (- 1,18) ✓ = 0, 91 V ✓ (4)
6.2.4 $Mn + Ni^{2+}$ ✓→ $Ni + Mn^{2+}$ ✓ Bal. ✓ (3)
6.2.5 Increases. ✓ (1)
6.2.6 - Increase in concentration of Ni^{2+} disturbs the equilibrium.✓
- The forward reaction is favoured in order to decrease the Ni^{2+}✓
- More electrons are transferred per unit time.✓ (3)
[19]

QUESTION 7

7.1 Chemical energy to electrical energy. (1)

7.2 $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ (2)

7.3 X^{3+} is the oxidising agent because it gains electrons and its oxidation number decreases from +3 to 0. (1)

7.4 - Pt is unreactive/Pt is a good conductor of electricity. (1)

7.5 Pressure: 101, 3kPa (1 atm) ✓; Temperature: 25ºC ✓ (2)

7.6 ✓ ✓ ✓

$X(s) \mid X^{2+}(aq) \parallel Cl_2(g) \mid Cl^-(aq) \mid Pt(s)$ (3)

7.7 $E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ ✓

2, 10 ✓= + 1, 36 – (X) ✓

X = - 0, 74 V ✓; therefore, X is Chromium (Cr). ✓ (5)

7.8 Increases. ✓ (1)

7.9 Adding $AgNO_3$ will form a precipitate ✓, AgCl, resulting in a decrease in chlorine ions (Cl^-) concentration✓. Therefore, the forward reaction is favoured. ✓

(3)

[19]

ELECTROLYTIC CELLS

QUESTION 1

1.1 C ✓✓ (2)

1.2 C ✓✓ (2)

1.3 D ✓✓ (2)

1.4 A ✓✓ (2)

[8]

QUESTION 2

2.1.1 A solution✓ that conducts electricity through the movement of ions. ✓ (2)

2.1.2 $E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ ✓ = - 0.13 ✓– (0,80) ✓ = - 0, 93 V ✓

EMF is negative; therefore, the reaction is non-spontaneous. ✓ (5)

2.2.1 $2C\ell^- \rightarrow C\ell_2 + 2e^-$ ✓✓ (2)

2.2.2 Hydroxide ions (OH^-/Sodium hydroxide/NaOH) ✓ and Hydrogen (H_2) ✓ (2)

2.2.3 Water (H_2O) is a stronger oxidising agent ✓ than Na^+ ion and water/H_2O will be reduced. ✓ (2)

[13]

QUESTION 3

3.1 The chemical process in which electrical energy is converted to chemical energy. ✓✓ (2)

3.2.1 $Cr^{3+}(aq) + 3e^- \rightarrow Cr$ ✓✓ (2)

3.2.2 $q = I\Delta t$ ✓

= (2,5)(10 x 60 x 60) ✓

= 9×10^4 C ✓ (3)

3.2.3 Q = n.qe

$9 \times 10^4 = n \times 1,6 \times 10^{-19}$ ✓; therefore, n = $5,63 \times 10^{23}$ electrons.

Nr. of Cr atoms = Nr. Electrons ÷ 3 = $5,63 \times 10^{23} \div 3$ ✓= $1,88 \times 10^{23}$

N = n. NA

$1,88 \times 10^{23} = n \times 6,02 \times 10^{23}$ ✓; n = 0, 31 mol

m = n.M = 0, 31 x 52 ✓= 16,12 g

m(X) = 16, 12 + 2, 2 ✓

= 18, 32 g ✓ (6)

[13]

QUESTION 4

4.1 Electrolytic. ✓ (1)

4.2 Q ✓ and T ✓

$Cu^{2+} + 2e^{-} \rightarrow Cu$ ✓✓ (4)

4.3.1 $C\ell_2$ / chlorine gas. ✓ (1)

4.3.2 Cu^{2+} ions / copper(II) ions. ✓ (1)

4.4 Cu is a stronger reducing agent ✓ than $C\ell^{-}$ ions ✓ and Cu will be oxidised ✓ to Cu^{2+}. (3)

[10]

QUESTION 5

5.1 Electrical energy to chemical energy. ✓ (1)

5.2 P ✓ (1)

5.3 $Ag^{+} + e^{-} \rightarrow Ag$ ✓✓ (2)

5.4 m = n.M; 3, 25 = n x 108 ✓ Therefore, n = 0, 03 mol

$n = \frac{N}{NA}$; $0,03 = \frac{N}{6.02 \times 10^{23}}$ ✓; $N = 1,81 \times 10^{22}$ electrons

$n = \frac{Q}{qe}$; $1,81 \times 10^{22} = \frac{Q}{1,6 \times 10^{-19}}$ ✓; Q = 2889, 6 C

$Q = I \times \Delta t$

2889, 6 = I (30 x 60) ✓

I = 1, 61 A ✓ (5)

[9]

QUESTION 6

6.1 The process in which electrical energy is converted to chemical energy. ✓✓ (2)

6.2 $2H_2O(\ell) + 2e^{-}$ ✓ $\rightarrow H_2(g) + 2OH^{-}(aq)$ ✓ (2)

6.3 X to Y ✓ (1)

6.4 V = n.Vm; $300 \times 10^{-3} = n \times 24$ ✓ Therefore, n = 0, 0125 mol

$n_{(e-)} = 2n_{(C\ell_2)} = 2(0,0125)$ ✓ = 0,025 mol

$0,025 = \frac{N}{6.02 \times 10^{23}}$ ✓, therefore, $N = 1,505 \times 10^{22}$ electrons ✓ (4)

[9]

MOMENTUM AND IMPULSE

SOLUTIONS

QUESTION 1

1.1 B ✓✓ (2)

1.2 C ✓✓ (2)

1.3 D ✓✓ (2)

1.4 D ✓✓ (2)

1.5 A ✓✓ (2)

[10]

QUESTION 2

2.1 Impulse is the product of the (net/average) force and the time during which the force acts. ✓✓ (2)

2.2 $F_{net}\Delta t = \Delta p$ ✓

$= m(v_f - v_i)$

$= 0,15(3,62 - (-6,2))$ ✓ (3)

= 1,473 N·s / kg·m·s^{-1} ✓ upward

2.3 $(U + K)_{top} = (U + K)_{bottom}$ ✓✓

$mgh_f + ½ mv_f^2 = mgh_i + ½ mv_i^2$ (0,15)(9,8)h + 0 ✓

= 0 + ½(0,15)(6,2)2 ✓

∴ h = 1,96 m✓ (5)

[10]

QUESTION 3

3.1 The total mechanical energy/sum of gravitational potential energy and kinetic energy, in an isolated system remains constant/is conserved. ✓✓ (2)

3.2 Total $E_{mech(top)}$ = Total $E_{mech(bottom)}$ ✓

$(E_p + E_k)_{top} = (E_p + E_k)_{bottom}$

$(mgh + ½mv^2)_{top} = (mgh + ½mv^2)_{bottom}$

(2)(9,8)(1,5) + 0✓ = 0 + ½(2)v_2 ✓

v = 5,42 m·s^{-1}✓ (4)

3.3.1 Δp = mvf – mvi✓

$F_{net}Δt$ = Δp

= 2(5,42 – 0) ✓

= 10,84 kg·m·s^{-1} right✓ (3)

3.3.2 10,84 kg·m·s^{-1} left /opposite direction ✓ (1)

3.4 $Δp_A = mv_f – mv_i$

Σpi = Σpf

10,84 = 1,5(v_f – 0) ✓ **OR** 0 = 1,5v_f + (2)(5,42) ✓

v_f = –7,23 m·s^{-1} v_f = –7,23 m·s^{-1}

v = 7,23 m·s^{-1} ✓ v = 7,23 m·s^{-1} ✓

(4)

[12]

QUESTION 4

4.1 <u>The product of the resultant/ net force</u> acting on an object and the <u>time the net force acts on an object</u>. ✓ ✓ (2)

4.2 Impulse = m = $\frac{Y2-Y1}{X2-X1}$ ✓

= $\frac{20-10}{10-5}$ ✓

= 2 N.s upwards ✓ (3)

4.3 Δp = mv_f - mv_i ✓

- 2 = 0,06 × v_f - 0,06 × 15v_f ✓

= 18,33 m·s^{-1} upwards ✓ (3)

4.4 Decreases ✓ (1)

4.5 Rubber mat increases contact time ✓

$$F_{net} \propto \frac{1}{\Delta t}$$ ✓

(2)

[10]

QUESTION 5

5.1 The total linear momentum of an isolated system remains constant. ✓ (2)

5.2

$$\left.\begin{array}{c} E_{mechB} = E_{mech\,A} \\ (E_p + E_k)_B = (E_p + E_k)_A \end{array}\right\} \checkmark \text{ any}$$

$$(mgh + \tfrac{1}{2}mv^2)_B = (mgh + \tfrac{1}{2}mv^2)_A$$

$$((0,4)(9,8)(0,2) + (0))_B \checkmark = (0 + \tfrac{1}{2}(0,4)v^2)_A \checkmark$$

$$v^2 = 3,92$$

$$v = 1,98 \text{ m·s}^{-1} \checkmark$$ (4)

5.3

$$\left.\begin{array}{c} \Sigma p_i = \Sigma p_f \\ m_A v_{iA} + m_B v_{iB} = m_A v_{fA} + m_B v_{fB} \end{array}\right\}$$

$$\underline{(0,4)(1,98) + (0,6)(0)} \checkmark = (0,4 + 0,6)\, v_{fAB} \checkmark$$

$$v_{fAB} = \underline{0,792 \text{ m·s}^{-1}} \checkmark \ \underline{\text{to the right}} \checkmark$$ (4)

5.4 Elastic ✓ (1)

[11]

QUESTION 6

6.1 The total linear momentum of an isolated system remains constant (is conserved). ✓✓ (2)

6.2

$$\left.\begin{array}{c} \Sigma p_i = \Sigma p_f \\ m_c v_{ic} + m_t v_{it} = m_c v_{fc} + m_t v_{ft} \end{array}\right\} \checkmark \text{any one}$$

$$(1\,200)(25) + (6\,000)(15) \checkmark = (1\,200)(16) + (6\,000)(v_{ft}) \checkmark$$

$$v_{ft} = 16,8 \text{ m·s}^{-1} \text{ east} \checkmark$$ (4)

6.3

$$E_{K(before)} = \tfrac{1}{2}m_c v_{ic}^2 + \tfrac{1}{2}m_t v_{it}^2 \checkmark$$

$$= \tfrac{1}{2}(1\,200)(25^2) + \tfrac{1}{2}(6\,000)(15^2) \checkmark = 1\,050\,000 \text{ J}$$

$$E_{K(after)} = \tfrac{1}{2}m_c v^2_{fc} + \tfrac{1}{2}m_t v^2_{ft}$$

$$= \tfrac{1}{2}(1\,200)(16^2) + \tfrac{1}{2}(6\,000)(16,8^2) \checkmark$$

$$= 1\,000\,320 \text{ J}$$

$$E_{K(lost)} = E_{K(after)} - E_{K(before)}$$

$$= 1\,000\,320 - 1\,050\,000 \checkmark$$

$$= 4\,980 \text{ J} \checkmark$$ (5)

6.4 Collision is inelastic. ✓ Energy is lost as sound energy and heat during the collision with the ground. ✓ (2)

[13]

QUESTION 7

7.1 The product of an object's mass and its velocity ✓ ✓ (2)

7.2

$$\text{Gradient} = \frac{1,53-7,84}{1,0-0,8} \qquad a = -31,55 \text{ m·s}^{-2} \checkmark$$

$$F_{net}\Delta t = \Delta p$$

$$F_{net}(0,2) \checkmark = (5)(1,53 - 7,84) \checkmark$$

$$F_{net} = -157,75 \text{ N}$$

$$= 157,75 \text{ N (upwards)} \checkmark$$ (4)

7.3 Inelastic ✓

The velocity/speed before is greater than the velocity/speed after the collision Total kinetic energy is not conserved ✓ **OR**

If calculation is given:

Total E_k before = ½ mv^2

= ½ $(5)(7,84)^2$ ✓

= 153,664 J

Total E_k after = ½ mv^2

= ½ $(5)(1)^2$ ✓

= 2,5 J

Total E_k before is not equal to total E_k after (4)

7.4
- The two balls will undergo the same change in momentum to stop.✓
- The rubber ball will take longer to stop as it is soft. The net force is inversely proportional to the time of impact if change in momentum is constant.✓
- The force needed to stop the rubber ball is small enough for the glass not to break.✓ (3)

[13]

QUESTION 8

8.1 The product of the resultant/net force acting on an object and the time the (2)

8.2. $F_{net}\Delta t = \Delta p$

$F_{net}(0,01) = 0 - 0,15v_i$ ✓ .... eq (1)

$F_{net}(0,03) = 4,5 - 0,15v_i$ ✓ .... eq (2)

$4,5 - F_{net}(0,03) = 0 - (0,01)F_{net}$

F_{net} = <u>225 N to the right/ opposite to the original direction of the ball</u> ✓ (3)

8.3 $F_{net}\Delta t = \Delta p$

$F_{net}\Delta t = p_f - p_i$ ✓ Any one

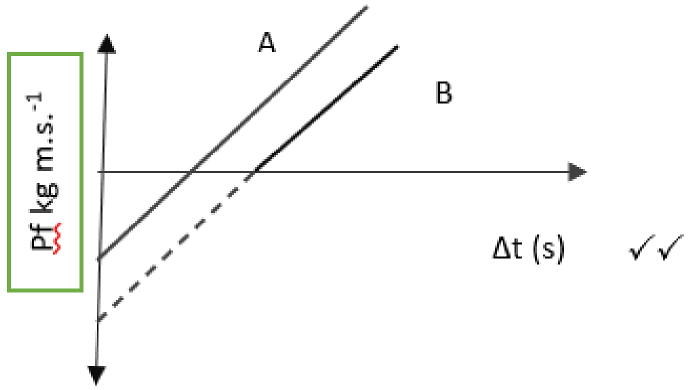
$F_{net}\Delta t = mv_f - mv_i$

<u>(225)(0,03)</u> ✓ = <u>$4,5 - (0,15)v_i$</u> ✓

$v_i = -15\ m\cdot s^{-1}$

$v_i = 15\ m\cdot s^{-1}$✓ (4)

8.4 (2)



[11]

QUESTION 9

9.1 The product of the resultant/net force acting on an object and the time the net force acts on the object. ✓✓ (DO NOT ACCEPT change in momentum) (2)

9.2 Impulse = Area under the graph
= ½ b x h
= ½ x (15 x 10^{-3}) x 64,13 ✓
= 0,481 N·s ✓ (accept kg·m·s^{-1}) (2)

9.3
0,481 kg·m·s^{-1} ✓ upwards/up ✓ (2)

9.4 **can use up as + or down as +**
$F_{net}\Delta t = \Delta p$ ✓
0,481 = m ($v_f - v_i$)
0,481 ✓ = 0,05 (v_f – (– 5,42) ✓
v_f = 4,2 m·s^{-1} ✓ (upwards) (4)

9.5 INCREASE ✓
The change in momentum will be constant✓
The hard ball will take less time to bounce off the force sensor, ✓
The force is inversely proportional to the time, the force will increase as the time of contact will decrease. (3)

[13]

QUESTION 10

10.1 The total linear momentum of an isolated system remains constant (is conserved) ✓✓ (2)

10.2 LEFT ✓✓ (2)

10.3 $\Delta p = m(v_{Bf} - v_{Bi})$ ✓
2,4 ✓= 0,3(v_{Bf} - 15)✓
2,4 = 0,3 v – 4,5 ✓
v_{Bf} = 23 m·s^{-1} ✓ (5)

[9]

QUESTION 11

11.1 The total linear momentum of a closed system remains constant (is conserved) ✓✓ (2)

11.2
$\sum p_{before} = \sum p_{after}$
$m v_{igirl} + m v_{iboy} = (m_{girl} + m_{boy}) v_f$ ✓

$(53)(-5) + (68)(7) = (53 + 68)v_f$ ✓

$211 = 121 v_f$ ✓

$v_f = 1{,}74\ m \cdot s^{-1}$ forward✓ or right (indicated on illustration) ✓

(5)

11.3.1 Decrease✓ (1)

11.3.2 According to the impulse-momentum theorem, the net force acting on an object (in this case the girl) is inversely proportional to the contact time ✓ As the girl bends her knees, she prolongs the contact time between herself and the ground, and the force exerted on her, is smaller.✓

(2)

[10]

QUESTION 12

12.1 The total linear momentum of a closed system remains constant (is conserved) ✓✓ (2)

12.2
$\sum p_{before} = \sum p_{after}$
$m v_{ix} + m v_{iy} = (m v_{fx}) + m v_{fy}$ ✓ any one

$10(2) + (2)(-4) = 10(x) + 2(y)$ ✓

$Y = 6 - 5(x)$ ………………… equation 1

$E_{kbefore} = E_{kafter}$
$\frac{1}{2} m v_i^2 + \frac{1}{2} m v_i^2 = \frac{1}{2} m v_f^2 + \frac{1}{2} m v_f^2$

$\frac{1}{2}(10)(2)^2 + \frac{1}{2}(2)(-4)^2 = \frac{1}{2}(10)(x)^2 + \frac{1}{2}(2)(y)^2$ ✓

$36 = 5x^2 + y^2$ ……… equation 2

Substitute Equation 1 into equation 2:

$36 = 5x^2 + (6 - 5(x))^2$ ✓

$x = 0$ and $x \neq 2$

$y = 6 - 5(x)$ ✓

$y = 6 - 5(0)$

$y = 6\ m.s^{-1}$

$x = 0\ m \cdot s^{-1}$ ✓

$y = 6 m \cdot s^{-1}$ to the right ✓ (7)

[9]

QUESTION 13

13.1 Product of mass and the velocity ✓✓ (2)

13.2 Cart A = $2\ m \cdot s^{-1}$ ✓ Cart B = $1{,}5\ m \cdot s^{-1}$✓

13.3.1 $\sum p_{before} = \sum p_{after}$
$m_v{}_{igirl} + m_v{}_{iboy} = (m_{girl} + m_{boy})\, v_f$ ✓ any one

$(1)(2) + (2)(-5) = (1 + 2)\ v_f$

$v_f = 0{,}33\ m.s^{-1}$ east

13.3.2 $F_{net}\,\Delta t = \Delta p$
$F_{net}\,(0{,}02) = 1\,(-0{,}33) - 1(2)$
$F_{net} = -116,\ 4\ N$ (West)

RATES OF REACTION
QUESTION 1

1.1 C✓✓ (2)

QUESTION 2

2.1 n = $m/\ M$ ✓ = = 12 /100 ✓ = 0,12 mol ✓ (3)

2.2 $N_{(caco3)}$=0.12 mol $n_{(HCl)}$= c ×V =3×0.2√= 0.6 mol✓
$CaCO_3$:HCl
1 : 2 ✓
0.12:0.24
0.24< 0.6 HCl is in excess ✓
(4)

2.3 4 minutes has a higher rate ✓than 8 minutes (1)

2.4 As the reaction proceeds, the concentration of the HCℓ decreases. ✓
This means fewer particles per volume. ✓
Fewer effective collisions per unit time. ✓ (3)

2.5 3,25 g✓ (1)

2.6 $n_{(CaCO3)}$=0.12 mol
$n_{(CO2)}$=n($CaCO_3$)=0.12 mol✓ m(CO_2)=m×M = *0.12 × 44* ✓ = 5.28g
%yield = $^{\text{actual mass}}/_{\text{theoritical mass}} \times 100$✓ = $^{3.25}/_{5.28}$ ×100✓ *= 61.55%*✓

2.7.1 Steeper ✓ (1)

2.7.2 No change ✓ (1)

[19]

QUESTION 3

3.1 Change in concentration of reactants or products ✓per unit time. ✓ (2)

3.2 Concentration of $Na_2S_2O_3$✓ (1)

3.3 More particles per unit volume ✓
More effective collisions per unit time ✓
Higher/faster rate of reaction. ✓ (3)

3.4.1

$n_{(Na_2S_2O_3)}$=cV =(0.10)(0.025)✓ 0.0025 mol

n(HCl)=cV = (0.15)(0.005) ✓ = 0.00075 mol

HCl: $Na_2S_2O_3$

2:1 ✓

Only 0.00075 mol of HCl available therefore HCl is limiting✓ (4)

3.4.2 HCl: S

2:1

0.00075: 3.75×10^{-4}✓ n=$\frac{N}{N_A}$ = $(3.75\times 10^{-4})(6.02 \times 10^{23})$ N=2.26×10^{20}

(3)

[13]

QUESTION 4

4.1.1 Surface Area✓ (1)

4.1.2 Increase in surface area increase the rate✓✓ (2)

4.1.3 Fair.Because its comparism of the same substance, mass, temperature and concentration✓✓ (2)

4.1.4 Equal to✓. Surface area affect only the rate not the amount of carbon dioxide produced✓✓ (3)

4.2.1 Concentration ✓ (1)

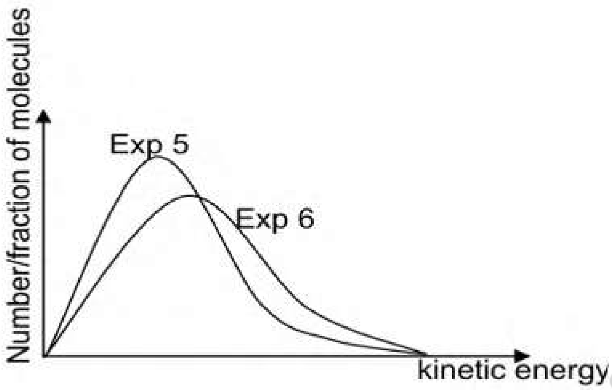
4.2.2 What is the realationship between concentration and rate✓✓ (2)

4.2.3 Fair comparism of the same substance, mass, temperature and state of division✓✓✓ (3)

4.2.4 Larger Than✓ because $CaCO_3$is limiting✓ (2)

4.3.1 Lower ✓

4.3.2



✓✓✓ (3)

4.4.1 Exothermic heat of reactants greater than heat of products✓✓ (2)

4.4.2 A✓ (1)

4.4.3 C-B✓ (1)

QUESTION 5

5.1 Change in concentration of product or reactants per unit time✓✓ (2)

5.2 Time ✓

Volume of Gas ✓ (2)

5.3 **For experiment II**
- More (HCl) particles per unit volume✓
- More effective collission per unit time✓
- Higher reaction rate✓ (3)

5.4 n=-$\frac{\Delta n}{\Delta t}$✓ $4.4\times10^{-3}=\frac{n_f-0.016}{2.5-0}$✓=0.005 mol✓ (3)

5.5 n(CO_2)=3n($Al_3(CO_3)$)=3(0.016)=0.048 mol ✓ n= $\frac{V}{V_m}$ 0.048=$\frac{V}{2400}$✓ v=1152 cm^3✓ (3)

[13]

QUESTION 6

6.1 Exothermic ✓ $\Delta H < 0$ ✓ (2)

6.2 Carbon dioxide (CO_2) gas escapes ✓✓ (2)

6.3 189 g✓ (1)

6.4.1 11 min ✓ (1)

6.4.2 EQUAL TO ✓
The amount of $CaCO_3$ consumed is equal to the amount of CO_2 produced / the mol ratio of $CaCO_3$ to CO_2 is 1 : 1. ✓
The time taken for consumption and production is the same. ✓ (3)

6.4.3 $n=\frac{m}{M}$ ✓ $n=\frac{200-185}{44}$✓ $=0.34\,mol$ n=$\frac{v}{v_m}$ ✓v=(0.34)(24000) ✓ V=8160cm^3✓ (5)

6.4.4 n(CO_2)=n($CaCO_3$)=0.34 mol✓ n= $^m/_M$ m=(0.34)(100) ✓ m=34g
rate= -$\frac{\Delta m}{\Delta t}$ =-$\frac{0-34}{11}$ ✓ =3.09 $g.min^{-1}$✓ (4)

6.5.1 A(n) decrease / increase in temperature will decrease / increase the reaction rate. ✓✓ (2)

6.5.2 INCREASES✓ (1)

6.5.3 Higher temperature means the average kinetic energy of the particles increases✓
More particles will have sufficient kinetic energy / more particles will have kinetic energy equal to or higher than the activation energy✓
More effective collisions per unit time / Frequency of the effective collisions increases✓ (3)

[23]

CHEMICAL EQUILIBRIUM
SOLUTIONS
QUESTION 1

1.1 A ✓✓ (2)
1.2 B✓✓ (2)
1.3 B✓✓ (2)
1.4 B✓✓ (2)
1.5 A✓✓ (2)
1.6 A✓✓ (2)
1.7 C✓✓ (2)
1.8 A✓✓ (2)
1.9 B✓✓ (2)

QUESTION 2

2.1.

2.1.1

Reversible reaction✓

2.1.2

Endothermic ✓ ΔH is positive ✓

2.1.3 Larger than ✓ K_c > 1✓

2.1.4 $n = \frac{m}{M} = \frac{168}{28}$ ✓$= 6\ mol$

	CO_2	CO
Initial Quantity (mol)	x	0
Change (mol)	3	6✓✓
Quantity at equilibrium (mol)	$x - 3$✓	6
Equilbrium Concentration (mol)	$\frac{x-3}{2}$✓	3

$K_c = \frac{[CO]^2}{[CO_2]}$ ✓

14 ✓$= \frac{(3)^2}{\frac{x-3}{2}}$ ✓

X=4,29 mol✓

(9)

2.2.1 Remains the same (1)

2.2.2 Decreases (1)

2.2.3 Increases (1)

{17}

QUESTION 3

3

3.1 When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will cancel/oppose the disturbance. ✓✓ (If "isolated system" is used: -1) (2)

3.2 Chemical) equilibrium. / Concentrations of reactants and products remain constant. (1)
Rate of the forward and reverse reactions are equal. ✓

3.3 Exothermic✓ (1)

3.4 With an increase in temperature the endothermic reaction is favoured. ✓ (2)
The reverse reaction is favoured. / Equilibrium shifts to the left. /
Reactants/[P2Q] increase(s). OR Products/[PQ2] decrease(s) ✓

3.5 Less than✓ (1)

3.6

	P_2Q	PQ_2
Initial concentration ($mol.dm^{-3}$)	x	0
Change in concentration ($mol.dm^{-3}$)	0,175✓	0,35
Equilibrium Concentration ($mol.dm^{-3}$)	$x - 0175$ ✓	0,35

$kc = \frac{\{PQ_2\}^2}{\{P_2Q\}}$ ✓✓

0.49✓ $= \frac{0,35^2}{x-0,175}$✓

$x = 0,425\ mol.dm^{-3}$

$n(P_2\,Q) = CV$

$= (0.425)(2)$✓

$= 0.85\ mol$✓

(8)

3.7 Pressure was decreased /Volume of the container was increased✓ (1)

3.8 The reaction that increases the number of moles (of gas) is favoured. ✓ [P2Q] increase✓ (2)

{18}

QUESTION 4

4

4.1 The stage in a chemical reaction where the rate of the forward reaction is equal to the rate of the reverse reaction ✓✓ (2)

4.2

4.2.1 (1)

Negative✓

4.2.2 (3)

- Increase in temperature favours endothermic reaction ✓
- Reverse reaction is favoured ./Concentration of reactant increases./Concentration of products decreases✓
- Forward reaction is favoured✓

4.2.3

OPTION 1

	P	Q_2	PQ	
Initial quantity (mol)	0,8	0,8	3,2	✓(a)
Change (mol)	0,4 ✓(b)	0,2	0,4	✓(c)
Quantity at equilibrium (mol)/	1,2	1,0	2,8	✓(d)
Equilibrium concentration ($mol{\cdot}dm^{-3}$)	0,6	0,5	1,4	✓(e)

$K_c = \frac{[PQ]^2}{[Q_2][P]^2}$ ✓(f)

$= \frac{1,4^2}{(0,5)(0,6)^2}$ ✓(g)

$= 10,889$ ✓ (h)

No K_c expression, correct substitution: Max. $\frac{7}{8}$

Wrong K_c expression: Max. $\frac{5}{8}$

(8)

4.2.4 Remains the same✓ Only temperature can change Kc.✓ (1)

4.3.1 Increases✓ (1)

4.3.1 Increases✓ (1)
4.3.2 Decreases✓ (1)

{18}

QUESTION 5

5.1

5.1.1 2 ($mol.dm^{-3}$) ✓ (1)

5.1.2 When the equilibrium in a closed system is disturbed, the system will re-instate a (new) equilibrium ✓ by favouring the reaction that will cancel/oppose the disturbance. ✓ (3)

5.1.3 Cooled✓ (1)

5.1.4 A decrease in temperature favours exothermic reaction /An increase in temperature favours an endothermic reaction ✓
The forwad reaction is favoured /HI concentration increases/Equilibrium shifts (Position) to the right✓
The forward reaction is exothermic /Reverse reaction is endothermic✓ (3)

5.2

5.2.1 Products can be converted back to reactants.✓ (1)

5.2.2

__Marking criteria__

a) $\Delta n(N_2O_4) = n(N_2O_4)_{eq} - n(N_2O_4)_{ini}$. ✓
b) __USING__ ratio:
$n(NO_2) : n(N_2O_4) = 2 : 1$ ✓
c) $n(NO_2)_{eq} = n(NO_2)_{ini} - \Delta n(NO_2)$ ✓
d) Divide BOTH by 1 dm^3 ✓
e) Correct K_c expression (__formulae in square brackets__). ✓

	NO_2	N_2O_4	
Initial amount (moles)	x	0	
Change in amount (moles)	1,62	0,81 ✓ (a)	ratio ✓ (b)
Equilibrium amount (moles)	x – 1,62 ✓ (c)	0,81	
Equilibrium concentration ($mol \cdot dm^{-3}$)	x – 1,62	0,81	÷ dm^3 ✓ (d)

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark (e)$$
$$= \frac{(0,81)}{(x-1,62)^2}$$

Wrong or no K_c expression: Max.. $^4/_5$

(5)

5.2.3

	NO_2	N_2O_4
Initial amount (moles)	x- 1,62	1,6✓
Change in amount (moles)	1,2	0,6✓
Equilibrium amount (moles)	X- 1,62 +1,2	1✓
Equilibrium concentration ($mol.dm^{-3}$)	x-0,42	1

$K_c = \frac{[N_2O_4]}{[NO_2]^2}$

$\frac{(0,81)}{(x-1,62)^2}$ ✓ $= \frac{1}{(x-0,42)^2}$ ✓ ✓

x=12,42 (mol) (6)

{20}

QUESTION 6

6.1

6.1.1 Remains the same✓ (1)

6.1.2 Decreases✓ (1)

6.1.3 Remain the same✓ (1)

6.2
- When the volume is increased, the pressure decreases.
- According to Le Chatelier's principle, the system will favour the reaction that produces more moles of gas. ✓
- The forward reaction produces more moles of gas
- The forward reaction is favoured. ✓

6.3
- Mass of CO_2 reacted:
  - Δm(C) = Initial mass - Equilibrium mass
  - Δm(CO_2) = 14.0 g – 4.44 g✓ = 9.56 g
- Moles of C reacted:
  - n = m / M
  - n(C) = 9.56 g / 12 g·mol^{-1} ✓= 0.797 mol
- Moles of C reacted (from mole ratio C:CO_2 is 1:1):
  - n(CO_2) reacted = 0.797 mol✓
- Mass of C reacted:
  - m = n × M
  - m(C) = 0.797 mol × 44 g·mol^{-1}✓ = 35.07 g
- Initial mass of C (X):
  - X = Initial mass - Mass reacted
  - X = 41.2 – 35.07 ✓ = 6.13 g✓

(6)

6.4
- Equilibrium moles:
  - $n(CO_2) = 6.13g / 44\ g{\cdot}mol^{-1} = 0.139\ mol$
  - $n(CO)$ formed = 2 × $n(CO_2)$ reacted ✓= 2 × 0.797 mol = 1.594 mol
- Equilibrium concentrations ($V = 3\ dm^3$):
  - $[CO_2] = n / V = 0.139 mol / 3\ dm^3 = 0.046\ mol{\cdot}dm^{-3}$
  - $[CO] = n / V = 1.594\ mol / 3\ dm^3 = 0.53\ mol{\cdot}dm^{-3}$ ✓

OR

	CO_2	2CO
Initial amount (moles)	0.936	0
Change in amount (moles)	0.797	1.594
Equilibrium amount (moles)	0.139	1.594
Concentration at equilibrium	0.046	0.53

- Kc calculation:
  - $Kc = [CO]^2 / [CO_2]$✓
  - $Kc = (0.53^2 / (0.046)$ ✓
  - $Kc = 6.10$✓

(5)

6.5 Y✓✓ (2)

6.6 Remain the same✓ (1)

{19}

QUESTION 7

7

7.1 The stage in a chemical reaction when the rate of forward reaction equals the rate of reverse reaction. ✓✓ (2)

7.2 $n = \frac{m}{M} = \frac{1,12}{28}$ ✓$= 0,04\ mol$

	$COBr_2$	CO	Br_2
Initial quantity(mol)		0	0
Change (mol)	0,04	0,04	0,04
Quantity at equilibrium		0,04	0,04✓
Equilibrium concentration		0,02	0,02

$Kc=\frac{CO]Br_2}{[COBr_2\}}$✓

0,19 ✓= $\frac{(0,02)^2}{[COBr_2\}}$ ✓ x= 0,00442 mol ∴ c($COBr_2$) = $2,11 \times 10^{-3}$ mol·dm^{-3} (7)

7.3 n ($COBr_2$) = cV = $2,11 \times 10^{-3} \times 2$✓

= $4,22 \times 10^{-3}$

n ($COBr_2$) initial = 0,04 + $4,22 \times 10^{-3}$✓

= 0,044 mol

%decomposed $\frac{0,04}{0,044}$ ✓$\times 100 = 90,46\%$✓

(4)

7.4 Kc < 0,19 ✓✓ (2)

7.5 Decreases ✓ A decreases in pressure favours the reaction that produces the larger number of moles/ volume (units) of gas. ✓ The forward reaction will be favoured. ✓ (3)

{17}

QUESTION 8

8

8.1.1 When the equilibrium in a closed system is disturbed, the system will re-instate a new equilibrium by favouring the reaction that will oppose the disturbance.✓✓

8.1.2 Percentage yield increases with an increase in temperature. ✓ Forward reaction is favoured. ✓Increase in temperature favours an endothermic reaction. ✓

8.1.3 When the pressure increases, the reaction that leads to a decrease in the number of moles will be favoured. ✓✓

8.1.4 I ✓✓

8.2

$n(PbS) = \frac{m}{M} = \frac{2,39}{239}$ ✓ $= 0,01$ mol

$n(H_2S)_{equilibrium} = n(PbS)$ ✓ $= 0,01$ mol

	H_2	H_2S	
Initial quantity (mol)	0,16	0	
Change (mol)	0,01	0,01 ✓	ratio ✓
Quantity at equilibrium (mol)	0,15 ✓	0,01	
Equilibrium concentration (mol·dm^{-3})	0,075	0,005	divide by 2 ✓

$K_c = \frac{[H_2S]}{[H_2]}$ ✓ $= \frac{0,005}{0,075}$ ✓ $= 0,067 \approx 0,07$ ✓

(9)

(19)

QUESTION 9

9.1

9.1.1 The stage in a chemical reaction when the rate of forward reaction equals the rate of reverse reaction. ✓✓ (2)

9.2

9.2.1 2✓ (1)

9.2.2 1✓ (1)

9.2.3 3✓ (1)

9.3

OPTION 1

$[A] = \frac{8}{3}$ ✓ $= 2,67\ mol\cdot dm^{-3}$

$[B] = \frac{4}{3}$ ✓ $= 1,33\ mol\cdot dm^{-3}$ } Divide by 3 dm^3 ✓

$[C] = \frac{12}{3}$ ✓ $= 4\ mol\cdot dm^{-3}$

$K_c = \frac{[C]^3}{[A]^2[B]}$ ✓ $= \frac{(4)^3}{(2,67)^2(1,33)}$ ✓ $= 6,75$ ✓ (7)

OPTION 2

	A	B	C	
Initial quantity (mol)	16	8	0	
Change (mol)	8	4	12	
Quantity at equilibrium (mol)	8 ✓	4 ✓	12 ✓	
Equilibrium concentration ($mol\cdot dm^{-3}$)	$\frac{8}{3}$	$\frac{4}{3}$	$\frac{12}{3}$	Divide by 3 dm^3 ✓

$K_c = \frac{[C]^3}{[A]^2[B]}$ ✓ $= \frac{(4)^3 ✓}{(2,67)^2(1,33)} = 6,75$ ✓

9.4 Endothermic ✓ (3)
- An increase in temperature) favours the reverse reaction. ✓
- An increase in temperature favours an endothermic reaction. ✓

ACIDS AND BASES
SOLUTIONS
QUESTION 1

1.1 C ✓✓ (2)
1.2 A ✓✓ (2)
1.3 A ✓✓ (2)
1.4 C ✓✓ (2)
1.5 B ✓✓ (2)
1.6 B ✓✓ (2)
1.7 D ✓✓ (2)
[14]

QUESTION 2

2.1.1 Strong ✓ (1)
2.1.2 Diprotic. ✓The acid can donate two hydrogen ions. ✓ (2)
2.1.3 Sulphate ion. ✓ (1)
2.2.1 Reaction of a salt and water. ✓✓ (2)
2.2.2 $HCO_3^- + H_2O$ ✓$\rightarrow HCO_3 + OH^-$✓ bal. ✓ (3)
2.3.1 $[H_3O^+] = 2 \times [H_2SO_4] = 2 \times 0,12$✓ $mol\cdot dm^{-3} = 0,24\ mol\cdot dm^{-3}$
pH=-log $[H_3O^+]$ ✓
pH= -log (0,24)✓
pH=0,62 ✓ (4)
2.3.2 Bromothymol blue✓
Reaction between a strong base and strong acid. ✓ (4)
2.3.3 Number of moles of NaOH in 16 ml.
n=cV
0,305 x 0,016 ✓
=0,00488 mol
Number of moles of H^+ in 20ml of acidic solution.

Ratio $OH^-:H^+ = 1:1$

$n(H^+) = 0,00488$ mol✓

number of moles of H^+ in 500ml

$n(H^+) = 0,00488 \times 25$✓$= 0,122$ mol

number of moles of H_2SO_4 in 500 ml

$n = cV = 0,12 \times 0,3$✓ $= 0,036$ mol

number of moles of H^+ in 0,036 mol of H_2SO_4 present in 500ml

Ratio $H^+:H_2SO_4 = 2:1$

$n(H^+) = n(\text{total } H^+) - n(H^+ \text{of} H_2SO_4) = 0,122 - 0,072$✓ $= 0,05$ mol

Number of moles of HCℓ in 500 ml.

ratio HCℓ: $H^+ = 1:1$

$n(HCℓ) = n(H^+) = 0,05$ mol✓

concentration of HCℓ in 200 ml

$c = \frac{n}{V}$ ✓

$c = \frac{0,05}{0,2}$ ✓

$= 0,25 \text{ mol·dm}^{-3}$✓ (10)

[27]

QUESTION 3

3.1 A substance that produces hydronium ions when dissolved in water. ✓✓ (2)

3.2 Strong acids ionise completely in water to form a high concentration of H_3O^+ ions. ✓✓ (2)

3.3 HCℓ ; $Cℓ^-$

Or H_2O ; H_3O^+✓✓ (2)

3.4.1. $c = \frac{n}{V}$ ✓

$0,8 = \frac{n}{0,15}$ ✓

$n = 0,12$mol✓ (3)

3.4.2 $c(NaOH) = \frac{n}{V}$ ✓

$n(NaOH) = (0,5)(0,06)$ ✓

$n(NaOH) = 0,03$ mol

Ratio: NaOH: HCℓ

1:1

0,03:0,03 mol in excess

$n(HCℓ)\text{reacted} = n_{initial} - n_{excess}$

$= 0,12 - 0,03$✓ $= 0,09$ mol

Mole ratio: $CaCO_3$:HCℓ 1:2

0,045:0,09✓

$n = \frac{m}{M}$

$0,045 = \frac{m}{100}$ ✓

$m = 4,5$ g✓ (6)

3.4.3 NO✓. It is a salt of a strong acid and a strong base. ✓ (2)

3.4.4 The equivalence point is at pH of 7. ✓

Bromothymol blue changes colour at a pH equal to 7. ✓The endpoint of this titration is within pH range of (6-7, 6) in which bromothymol blue/indicator changes colour. (2)

3.5 $KOH \rightarrow K^+ + OH^-$ ratio: 1:1✓
$K_w= [H_3O^+][OH^-]= 1 \times 10^{-14}$
$1 \times 10^{-14} = [H_3O^+][2,5 \times 10^{-7}]$ ✓
$[H_3O^+] = 0,4 \times 10^{-7}$ mol·dm^{-3}
$pH=-\log [H_3O^+]$
$=-\log (0,4\times10^{-7})$ ✓
$=7,3979$ ✓ (4)

3.6 Calculate the initial moles of H_2SO_4
$c=\frac{n}{V}$ ✓ n=1,0 (0,050) ✓ n=0,05 mol
Calculate the moles of NaOH used
n(NaOH)=0,5 (0,028) ✓ = 0,014 mol
Calculate the moles of H_2SO_4 left over
NaOH: H_2SO_4
n(NaOH)= ½ (0,0140) ✓ = 0,0070 mol
Calculate the moles of H_2SO_4 that reacted
0,05 – 0,007 ✓= 0,043 mol✓
Calculate moles of $CaCO_3$
$n=\frac{m}{M}$
m= 0,0430 x 100✓
m = 4,30g✓ (8)
[23]

QUESTION 4

4.1.1 Exothermic✓ Reaction that releases heat. Heat of reaction is negative/ Heat/energy of products less that Heat/energy of reactants. (2)
4.1.2 $HC\ell$ ✓ and $C\ell^-$ ✓ OR H_2O✓ and H_3O^+✓ (2)
4.1.3 Increases (1)
4.1.4 $[H_3O^+]$ increased, the reaction that decreases the $[H_3O^+]$ will be favoured. ✓
Reverse reaction if favoured✓ / concentration or amount of reactants increases. (2)
4.2 $m(CaCO_3)= 8 \times 0,95$✓
=7,6 g
$n(CaCO_3)= \frac{7,6}{100}$ ✓=0,076 mol
$n(HC\ell)=2 \times 0,076$✓
=0,152 mol

$c(HC\ell)= \frac{n}{V}$
V=0,5 x 0,152✓✓
V=0,304dm^3
V=304dm^3✓ (7)
[18]

QUESTION 5

5.1.1 Ionization is the process where a covalent molecule reacts with water to form ions.
✓✓ (2)
5.1.2 HSO_3^- and H_2O ✓✓ (2)
5.1.3. Ka value of $6,5 \times 10^{-8}$ is very small, a small Ka mean HSO_3^- is a weak acid and ionizes incompletely to form a low concentration of hydronium ions. ✓✓ (2)
5.1.4 H_2SO_3 ✓
5.2 n=cV✓
$n(H_2SO_4)$ initial = 0,5 x 0,0750✓ = 0,0375 mol (10)

n(NaOH)=0,5 x 0,028✓ = 0,014 mol
NaOH: H_2SO_4 : 2:1✓
n(H_2SO_4) excess = ½ (0,0140) ✓= 0,0070 mol✓
n(H_2SO_4) reacted= 0,0375 – 0,0070 ✓= 0,0305 mol
Ratio: 1:1
n($MgCO_3$) = 0,0305 mol✓

mass = 0,0305 x 84 =2,57115✓
%purity = $\frac{\text{pure mass}}{\text{impure mass}}$X 100

%= $\frac{2,57115}{3}$x 100✓
=85,7%✓

[18]

QUESTION 6

6.1.1 A solution with a known concentration✓✓ (2)

6.1.2 Strong. Dissociates completely in water to form a high concentration of hydroxide ions (2)

6.1.3 pH=-log [H_3O^+]
13,4 =-log [H_3O^+] ✓
[H_3O^+]= 3,981 x 10^{-14} mol·dm^{-3}✓
Kw = [H_3O^+][OH^-]
10^{-14} ✓= 3,981 x 10 $^{-14}$ [OH^-]✓
[OH-] = 0,25 mol·dm^{-3}✓ (5)

6.1.4 n(H_2SO_4)=cV✓
=(0,4)(3,125 x 10^{-3}) ✓
=1,25 x 10 $^{-3}$ mol

n(NaOH)=2n(H_2SO_4) ✓
=2 x 1,25 x 10 $^{-3}$
=2,5 x 10 $^{-3}$

n(NaOH)=cV
2,5 x10 $^{-3}$ = 0,25 V✓
V= 0,01 dm^3 (5)

6.2 n=$\frac{m}{M}$✓
n=$\frac{5}{84}$✓
=0,06 mol
n(HCℓ) reacted=n($NaHCO_3$)=0,06 mol✓
n(HCℓ) initial=cV
=(1,6)(0,05) ✓
=0,08 mol

n(HCℓ)unreacted =0,08 – 0,06✓
=0,02 mol

c=$\frac{n}{V}$
c=$\frac{0,02}{0,05}$✓ (7)

$=0,4\ mol{\cdot}dm^{-3}$
$[H_3O^+]=c(HC\ell)=0,4\ mol{\cdot}dm^{-3}$

$pH=-\log[H_3O^+]$
$=-\log 0,4$ ✓
$=0.4$✓

[21]

QUESTION 7

7.1.1	Ammonia ✓	(1)
7.1.2	It's a proton /H^+/ Hydrogen ion acceptor. ✓	(1)
7.1.3	Ammonium chloride✓	(1)
7.2.1	Hydrolysis is the reaction of a salt and water. ✓✓	(2)
7.2.2	$NH_4^+(aq) + H_2O(\ell)$ ✓$\rightarrow H_3O^+(aq) + NH_3(aq)$ ✓bal acidic✓	(3)
7.3.1	Burette✓	(1)
7.3.2	Yellow to blue✓	(1)
7.3.3	Equivalence point✓	(1)

7.3.4 $c=\frac{n}{V}$✓

$0,2=\frac{n}{0,02}$✓

$n(NaOH)=0,004\ mol$

H_2SO_4: ½ n(NaOH)

½ (0,004) ✓

0,002 mol

$c=\frac{0,002}{0.025}$✓

$c=0,08\ mol{\cdot}dm^{-3}$✓ (5)

7.3.5 $c=\frac{n}{V}(NaOH)$ ✓

$0,2=\frac{n}{0,035-0,02}$✓

$n=0,003\ mol$

$c=\frac{n}{V}$

$c=\frac{0,003}{0,035-0,025}$✓

$=0,3\ mol{\cdot}dm^{-3}$

$NaOH\rightarrow Na^+ + OH^-$ Ratio 1:1)

$[OH^-]=0,3\ mol.dm^{-3}$✓

$K_w = [H_3O^+][OH^-]=1\times10^{-14}$

$[H_3O^+]= =\frac{1\times10^{-14}}{0,3}$✓

$pH=-\log[H_3O^+]$

$=-\log 3,33\times10^{-14}$✓

$=13,47$✓ (7)

[23]

QUESTION 8

8.1.1	An acid is a proton (H^+ ion) donor✓✓	(2)
8.1.2	$HC\ell$ and $C\ell^-$ ✓✓ OR H_3O^+ and H_2O ✓✓	(2)
8.1.3	Solution I. ✓ HCℓ is a stronger acid than CH3COOH / HCℓ has a higher Ka ✓ (than CH_3COOH)	(3)

HCℓ will produce a higher concentration of H_3O^+ ✓ (than CH_3COOH) CH_3COOH is a weaker acid than HCℓ / CH_3COOH has a lower Ka (than HCℓ) CH_3COOH will produce a lower concentration of H_3O^+ (than HCℓ)

8.2.1 n=cV ✓
= 1 x(10 x 10^{-3})✓
= 0,01 mol ✓ (3)

8.2.2 pH = - log [H_3O^+] ✓
13 ✓ = - log [H_3O^+]
[H_3O^+] = 1 × 10^{-13} mol·dm^{-3}
[NaOH] = 0,1 mol·dm^{-3}✓
c = n V
0,1 = 0,01 ✓
V = 0,1 (dm^3)✓ (5)

8.2.3 $\frac{caVa}{cbVb} = \frac{na}{nb}$✓

$\frac{(0,09)(15)}{(0,1)\ Vb}$✓$=\frac{1}{2}$✓
V_b = 27 cm^3 = 0,027 dm^3
V(remaining) = 0,1 – 0,027 ✓ = 0,073 dm^3 ✓ (5)

8.3 Na_2CO_3
n=$\frac{m}{M}$✓
$\frac{0,29}{106}$✓
n_b = 0,003 mol
n(HCℓ) = 2n(Na_2CO_3) ✓
= 0,005 mol
c(HCℓ)dilute =$\frac{0,005}{0,05}$✓
= 0,1094 mol·dm^{-3}
cV(HCℓ)dilute = cV(HCℓ)conc
0,1094 x 500 ✓ = (HCℓ)conc x 5 ✓
c(HCℓ) conc = 10,94 mol·dm^{-3} ✓ (5)
[20]

QUESTION 9

9.1.1 A substance that can act as either acid or base✓✓ (2)

9.1.2 HSO_3^- ✓ (1)

9.1.3 H_2SO_3, HSO_3^- ✓✓and H_2O, H_3O^+✓✓ (2)

9.2 Bromothymol blue ✓
Is most suitable for a solution with a pH = 7✓ (2)

9.3.1 n(NaOH) = cV
= (1,2)(0,2) ✓
= 0,24 mol ✓ (2)

9.3.2 POSITIVE MARKING FROM QUESTION 9.3.1
Therefore (4 × 0,240 mol) ✓= 0,16 mol in 200 cm^3 ✓
$n_{used}(HNO_3) = n_{initial}(HNO_3) – n_{excess}(HNO_3)$
$n_{used}(HNO_3)$ = 0,24 − 0,160956 ✓ (9)

$n_{used}(HNO_3) = 0{,}079$ mol✓

$0{,}079✓ = \frac{m}{56}$ ✓

$m = 4{,}42$ g

$\%purity = \frac{\text{pure mass}}{\text{impure mass}} X\ 100$✓

$\% = \frac{4{,}42}{13}\ x\ 100$✓

$=34{,}05\%$✓

[19]

ORGANIC CHEMISTRY

SOLUTIONS

QUESTION 1

1.1 C ✓✓ (2)

1.2 B ✓✓ (2)

1.3 C ✓✓ (2)

1.4 D ✓✓ (2)

1.5 D ✓✓ (2)

1.6 B ✓✓ (2)

1.7 D ✓✓ (2)

[14]

QUESTION 2

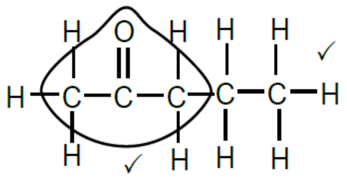
2.1 Organic compounds that consist of hydrogen and carbon only ✓✓ (2)

2.2.1 C and E ✓✓ (2)

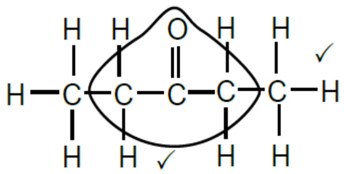
2.2.2 D and H ✓ (1)

2.2.3 A ✓ (1)

2.3.1



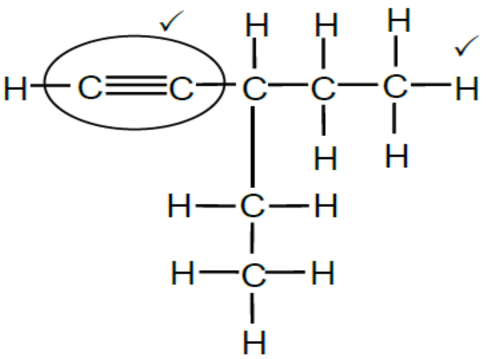
OR/OF



(2)

2.3.2 C_nH_{2n+2} ✓ (1)

2.3.3



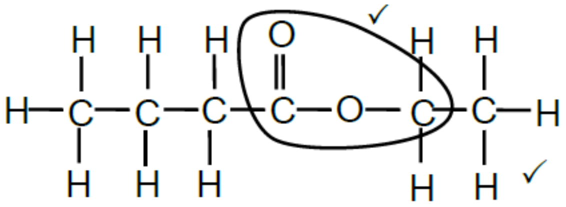
(2)

2.4.1	3-ethylhex-3-ene ✓✓✓	(3)
2.4.2	2,5-dichloro-2,4-dimethylhexane ✓✓✓	(3)
2.4.3	dimethylpropanal ✓✓	(2)
2.5	$C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ Reactants ✓products✓balancing✓	(3)
		[22]

QUESTION 3

3.1	Compounds with one or more multiple bonds between C atoms in the hydrocarbon chain ✓✓	(2)
3.2.1	E ✓	(1)
3.3.2	F ✓	(1)
3.3	Ketones ✓ Aldehydes ✓	(2)
3.4	Tertiary ✓ The -OH is bonded to a C which is bonded to three other C atoms. ✓	(2)
3.5.1	3-ethyl-4-iodohexane ✓✓✓	(3)
3.5.2	2-methylpropan-1-ol / 2-methy-1-propanol / methyl-1-propanol ✓✓	(2)
3.6.1	Esterification / condensation ✓	(1)

3.6.2



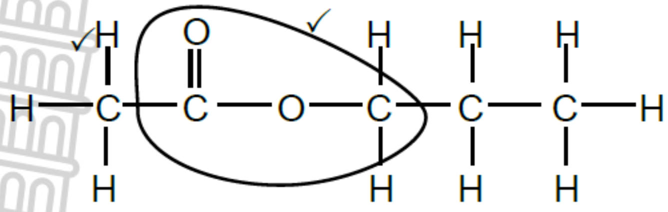
(2)

3.7.1	C_2H_4O ✓	(1)
		[17]

QUESTION 4

4.1.1	D ✓	(1)
4.1.2	A ✓	(1)
4.1.3	E ✓	(1)
4.2.1	3,3-dibromo-4,4-dimethylhexane ✓✓✓	(3)
4.2.2	4,4-dimethylpent-2-yne OR 4,4-dimethyl-2-pentyne ✓✓✓	(3)
4.3.1	Compounds with the same molecular formula but different functional groups/homologous series. ✓✓	(2)
4.3.2	A and C ✓	(1)
4.4.1	H_2SO_4 / sulphuric acid ✓	(1)
4.4.2	Esterification / condensation ✓	(1)

4.4.3 (2)



4.4.4 Propan-1-ol OR 1-propanol ✓✓ (2)

[18]

QUESTION 5

5.1.1 D✓ (1)

5.1.2 A and C✓ (1)

5.1.3 E and F✓ (1)

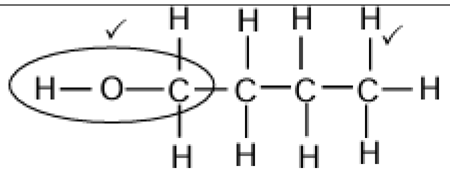
5.2.1 3-methylbutan-2-one ✓✓✓ (3)

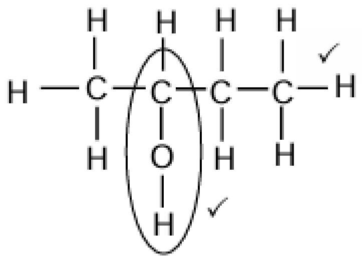
5.2.2 2,6-dichloro-2,5-dimethylheptane ✓✓✓ (3)

5.2.3 3-ethyl-2-methylhex-2-ene ✓✓✓ (3)

5.2.4

Marking criteria: • Hydroxyl group on the 1st C-atom.✓ • Whole structure correct.✓	**Marking criteria:** • Hydroxyl group on the 2nd C-atom.✓ • Whole structure correct.✓





(4)

5.3.1 Combustion/oxidation✓ (1)

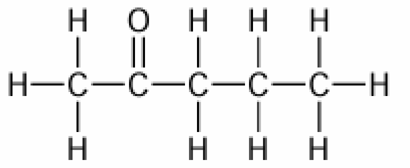
(5)

Marking criteria:	
(a) Volume O_2 and C_3H_8 used. (b) Volume CO_2 and H_2O produced (c) Volume O_2 remaining (d) Addition of the three volumes (e) Correct final answer 66 cm^3 or 0,066 dm^3	$V(O_2)_{used/gebruik} = 5V(C_3H_8)$ $= (5)(8)$ $= 40\ cm^3$ ✓ (a) $V(CO_2)_{formed/gevrom} = 3V(C_3H_8)$ $= (3)(8)$ $= 24\ cm^3$ $V(H_2O)_{formed/gevrom} = 4V(C_3H_8)$ $= (4)(8)$ $= 32\ cm^3$ ✓ (b) $V(O_2)_{unused} = 50 - 40 = 10\ cm^3$ ✓ (c) Volume gas in the container = $\boxed{10 + 24 + 32}$ ✓ (d) Total volume gas in the container = 66 cm^3 ✓ (e)

[22]

QUESTION 6

6.1.1 D ✓ (1)
6.1.2 A and D✓ (1)
6.1.3 E✓ (1)
6.2 C_nH_{2n+2}✓✓ (2)
6.3.1 B✓ (1)
6.3.2 Chain (isomer)✓ (1)
6.3.3 2,2,4-trimethylpentane ✓✓✓ (3)
6.4



Marking criteria:
- Functional group✓
- 5 C-atoms in the longest chain✓
- Whole structure correct ✓

(3)

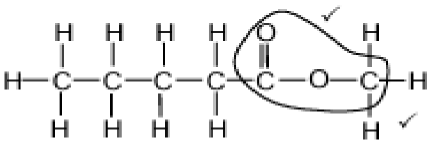
6.5.1 Esterification/condensation✓ (1)
6.5.2 H_2SO_4/sulphuric acid ✓ (1)
6.5.3 Propyl ✓ethanoate✓ (2)

[17]

QUESTION 7

7.1 Molecules/compounds containing carbon (atoms).✓ (1)
7.2.1 2,3-dimethylbut-1-ene✓✓ (2)
7.2.2 Butan-2-one/ butanone ✓✓ (2)

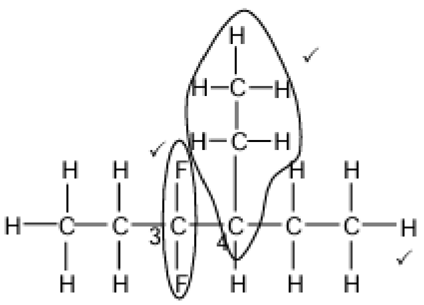
7.3.1



Marking criteria:
- Functional group correct.✓
- Whole structure correct.✓

(2)

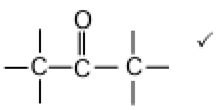
7.3.2



Marking criteria:
- Six C atoms in longest chain. ✓
- Two F atoms on third C atom. ✓
- Ethyl substituent on fourth C atom.✓

(3)

7.3.3 C_nH_{2n}✓ (1)
7.3.4



(1)

7.3.5 Methanol ✓✓ (2)
7.4.1 B✓ (1)
7.4.2 D and G✓ (1)
[16]

QUESTION 8

8.1 The pressure exerted by a vapour at equilibrium with its liquid in a closed system ✓✓ (2)

8.2.1 146 (kPa) ✓ (1)

8.2.2 **Comparing compound C with compounds A and B.**

- **Structure:**
  Compound C is more branched than compounds A and B / shorter chain length / smallest surface area. ✓
- **Intermolecular forces:**
  Compound C has weaker intermolecular forces / London forces than A and B. ✓
- **Energy:**
  Less energy is needed to overcome/break the intermolecular forces in compound C than in compounds A and B. ✓ (3)

8.3.1 E / butanal ✓ (1)

8.3.2 • Compound D/Propanoic acid has hydrogen bonding (dipole- dipole and London forces) between molecules. ✓
• Compound E/Butanal has dipole-dipole forces (and London forces) between molecules. ✓
• Intermolecular forces between molecules of compound D/propanoic acid are stronger than intermolecular forces between molecules of compound E/butanal. ✓
• More energy is needed to overcome/break intermolecular forces between molecules of compound D/propanoic acid than in compound E/butanal ✓
OR
• Compound D/Propanoic acid has hydrogen bonding (dipole-dipole and London forces) between molecules.
• Compound E/Butanal has dipole-dipole forces (and London forces) between molecules.
• Intermolecular forces between molecules of compound E/butanal are weaker than intermolecular forces between compound D/propanoic acid
• Lesser energy is needed to overcome/break intermolecular forces between molecules of compound E/butanal than in compound D/propanoic acid (4)
[11]

QUESTION 9

9.1 The temperature at which the vapour pressure of a substance is equal to the vapour pressure. ✓ ✓ (2)

9.2 C ✓ (1)

9.3 **Compound A**

- Longer chain length / larger surface area over which the intermolecular forces act ✓
- Stronger intermolecular forces ✓
- More energy is needed to overcome / break the intermolecular forces ✓

OR

Compound B

- Shorter chain length / smaller surface area
- Weaker intermolecular forces
- Less energy is needed to break / overcome the intermolecular forces (3)

9.4.1 75 °C ✓ (1)

9.4.2
- **Intermolecular forces:**
  C /butanol has stronger intermolecular forces than D /butanal. ✓
- **Energy:**
  More energy needed to overcome or break intermolecular forces. ✓

OR

- **Intermolecular forces:**
  D/butanal has weaker intermolecular forces than C/butanol
- **Energy:**
  Less energy is needed to overcome or break intermolecular forces.

OR

- **Intermolecular forces:**
  A is a more polar molecule than D increasing the intermolecular forces
- **Energy:**
  More energy is needed to overcome or break intermolecular forces

OR

- **Intermolecular forces:**
  Electron density of A is greater than that of D increasing the intermolecular forces
- **Energy:**
  More energy is needed to overcome or break intermolecular forces. (2)

9.5 Decreases ✓ (1)

[10]

QUESTION 10

10.1.1 A series of organic compounds that can be described by the same general formula. **OR** A series of organic compounds in which one member differs from the next by the CH_2 group. ✓✓ (2)

10.1.2 (a) Formyl group ✓ (1)

(b) Methanal ✓✓ (2)

10.1.3 (a) Homologous series / functional group / type of intermolecular forces / straight chain / atmospheric pressure ✓ (1)

(b) The boiling points of carboxylic acids increase with an increase in chain length/the number of carbon atoms/surface area/molecular mass ✓ (1)

(c) As the number of C atoms/chain length/molecular mass/surface area increases,

- The strength of intermolecular/London/dispersion forces increases. ✓
- More energy is required to overcome the intermolecular/London/dispersion forces. ✓ (2)

10.1.4 75 °C ✓ (1)

10.2
- Higher than ✓
- Compound B has two sites of hydrogen bonding between molecules and compound A has only one site of hydrogen bonding between molecules. ✓
- Intermolecular forces in compound B are stronger. ✓
- More energy is required to overcome the intermolecular forces in compound B. ✓ (4)

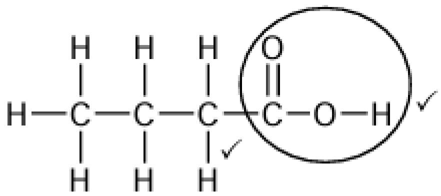
[14]

QUESTION 11

11. 1 A series of organic compounds that can be described by the same general formula. ✓ (1)

11.2 Ester✓ and carboxylic acid ✓ (2)

11.3.1



Marking criteria:
- Functional group correct. ✓
- Whole structure correct. ✓

(2)

11.3.2 Methyl propanoate/Propyl methanoate/Ethyl ethanoate ✓ ✓ (2)

11.4.1 Hydrogen bonds ✓ (1)

11.4.2 Dipole-dipole forces ✓ (1)

11.5 A✓ The hydrogen bond is stronger than the dipole-dipole force. ✓
OR The dipole-dipole force is weaker than the hydrogen bonds.
OR Compound A has stronger intermolecular forces (than B). (2)
OR Compound B has weaker intermolecular forces (than A).

11.6 Decreases ✓ (1)

[12]

QUESTION 12

12.1 The temperature at which the vapour pressure of a liquid is equal to the atmospheric pressure. ✓✓ (2)

12.2 **Compound C** **Compound B**

• Is more branched/compact/spherical/smaller surface area ✓ • Weaker intermolecular forces✓ • Less energy needed to break/overcome the intermolecular forces ✓	• Is less branched/compact/spherical/larger surface area • Stronger intermolecular forces (3) • More energy is needed to break/overcome intermolecular forces

12.3.1 117,7 (°C) ✓ (1)

12.3.2 • Between molecules of compound A are 2 sites of hydrogen bonds (in addition to London and dipole-dipole forces) ✓
• Between molecules of compound B is 1 site of hydrogen bonds (in addition to London and dipole-dipole forces) ✓
• Between compound D are dipole-dipole forces (in addition to London forces) ✓
• Intermolecular forces between molecules of B are weaker than those between molecules of A ✓ but stronger than those between molecules of D ✓
• Less energy needed to overcome intermolecular forces of B compared to that of A ✓/ More energy needed to overcome intermolecular forces of B compared to that of D (6)

12.4.1 Butane ✓✓ (2)

12.4.2

From compound E to G:	**From compound G to E**
• Chain length increases ✓ • Strength of intermolecular forces increases ✓ • More energy needed to overcome the intermolecular forces✓	• Chain length decreases • Strength of intermolecular forces decreases • Less energy needed to overcome the intermolecular forces (3)

[17]

QUESTION 13

13.1 The temperature at which the vapour pressure of a substance equals atmospheric pressure. ✓✓ (2)

13.2 The higher the molecular mass the higher the boiling point.
OR As the molecular mass increases the boiling point increases. OR The longer the C-chain the higher boiling point
OR The boiling point and the molecular mass are proportional.✓✓ (2)

13.3 • Strength of the intermolecular forces increases / More sites for London forces with increase of molar mass/chain length/surface area. ✓
• More energy is needed to overcome/break intermolecular forces.✓ (2)

13.4.1 Aldehyde✓ (1)

13.4.2 • Aldehydes/S have the weakest/weaker intermolecular forces.✓
• Therefore, aldehydes/S have the lowest/lower boiling points / least/lower energy needed to overcome intermolecular forces.✓
OR
• Carboxylic acids/P have the strongest intermolecular forces.

- Therefore, carboxylic acids/P have the highest boiling points / need most energy to overcome intermolecular forces. (2)

13.5.1 60 (g.mol^{-1})✓ (1)

13.5.2 Propan-1-ol ✓✓ (2)

13.6
- Carboxylic acids/B/Propanoic acid have, (in addition to London forces and dipole-dipole forces), two sites for hydrogen bonding between molecules.✓
- Alcohols/A/Butan-1-ol have, (in addition to London forces and dipole-dipole forces), one site for hydrogen bonding between molecules. ✓
- Intermolecular forces in carboxylic acids are stronger. ✓ (3)

[15]

QUESTION 14

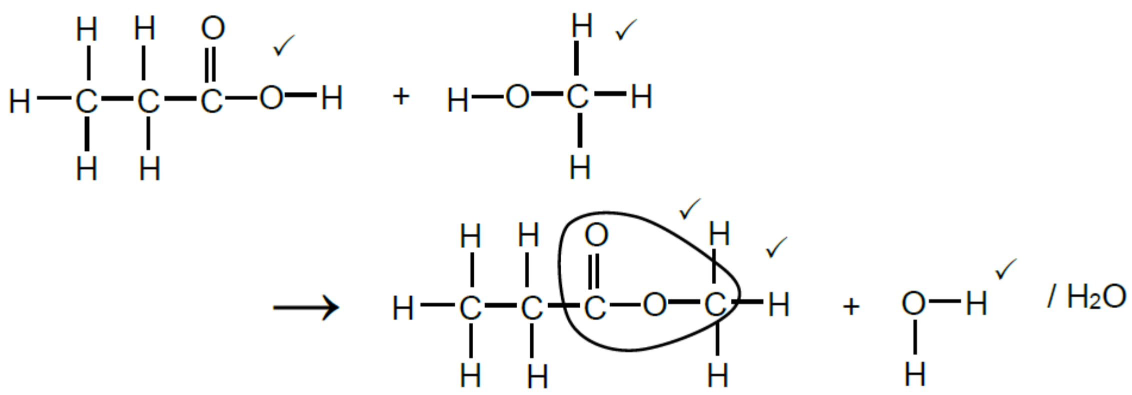
14.1.1 Sulphuric acid ✓ (1)

14.1.2 Esterification / condensation ✓ (1)

14.1.3
- Alcohol/methanol catches fire easily
- To heat evenly / increase temperature gradually
- Alcohol / methanol will evaporate too quickly/is volatile

(Any two) ✓✓ (2)

14.1.4



(5)

14.1.5 Methyl propanoate ✓✓ (2)

14.2.1 Hydrogen / H_2 ✓ (1)

14.2.2 3,3-dimethylbut-1-ene OR 3,3-dimethyl-1-butene ✓✓ (2)

14.2.3 Elimination OR dehydrohalogenation ✓ (1)

14.2.4 H_2SO_4/H_3PO_4 OR sulphuric acid/phosphoric acid ✓ (1)

14.2.5 3,3-dimethylbutan-2-ol OR 3,3-dimethyl-2-butanol ✓✓ (2)

14.2.6 Addition / hydration ✓ (1)

14.2.7 Secondary ✓ (1)

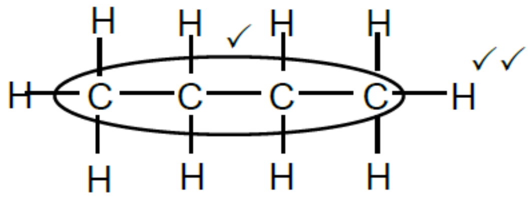
[20]

QUESTION 15

15.1 The chemical process/reaction in which longer chain hydrocarbon/alkane molecules/are broken down to shorter (more useful) molecules. ✓✓ (2)

15.2 Primary ✓
The halogen/bromine/functional group (-X) is bonded to a C atom that is bonded to one other C atom. ✓ (2)

15.3.1



(3)

15.3.2 C_8H_{18} ✓ (1)

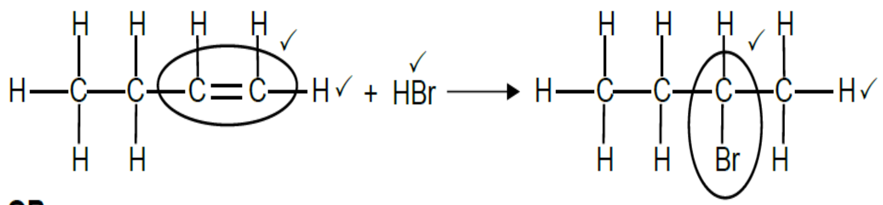
15.4.1 Br_2/Bromine ✓ (1)

15.4.2 Substitution ✓ (1)

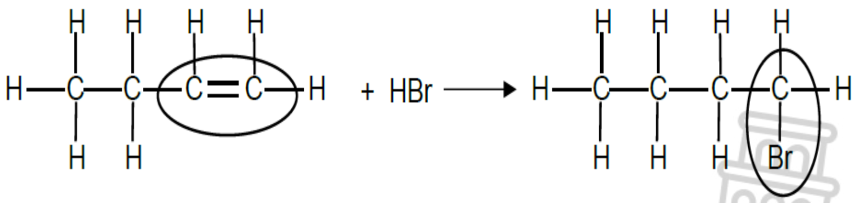
15.4.3 UV/(Sun)light/Heat ✓ (1)

15.5 Dehydrohalogenation/Dehydrobromination ✓ (1)

15.6.1

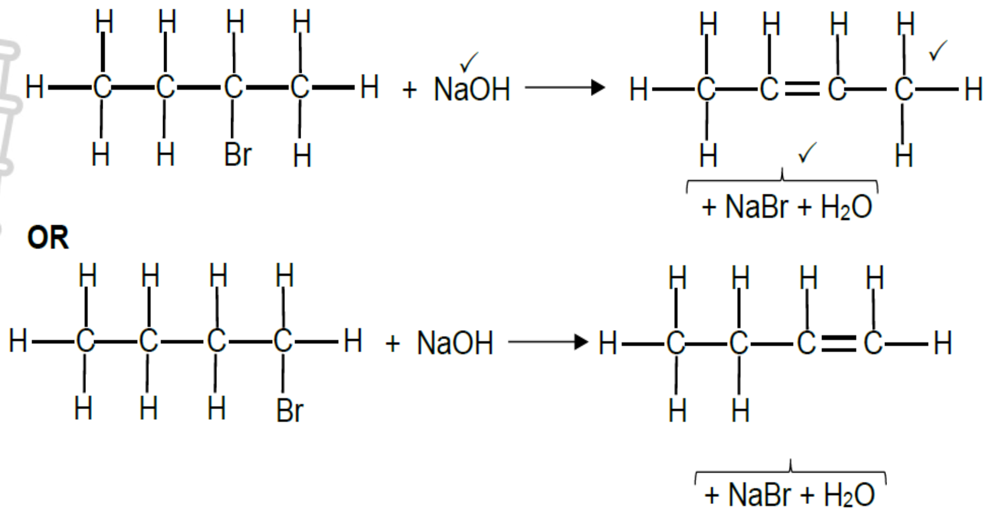


OR



(5)

15.6.2 (3)



15.6.3 But-2-ene OR But-1-ene ✓ ✓ (2)

[22]

QUESTION 16

16.1.1 Hydrogenation ✓ (1)

Dehydration ✓ (1)

16.2 Butan-1-ol ✓ ✓ (2)

16.3.1

$CH_2CHCH_2CH_3$ ✓ + H_2O ✓ → $CH_3CHOHCH_2CH_3$ ✓ ✓

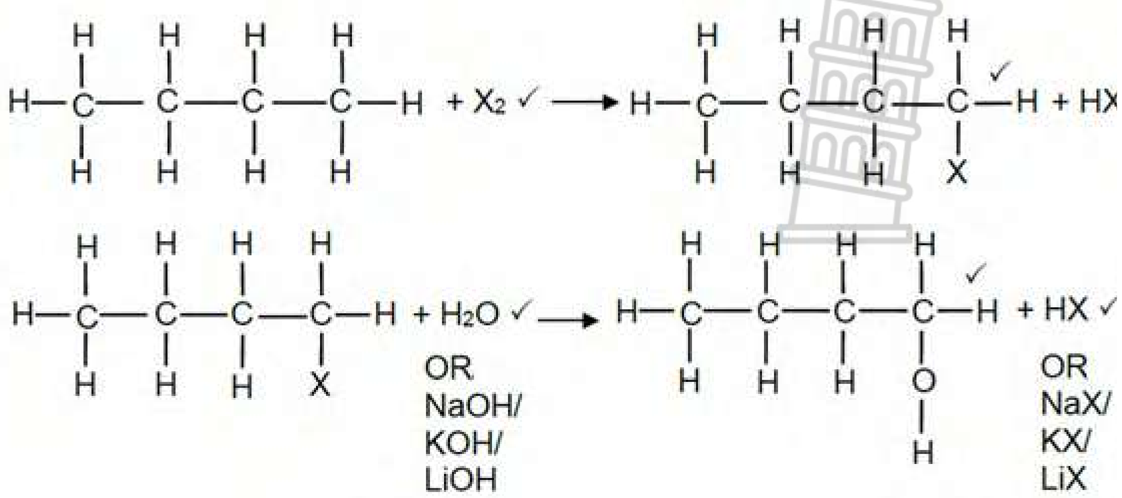
OR/OF

$CH_2{=}CHCH_2CH_3$ ✓ + H_2O ✓ → $CH_3CH(OH)CH_2CH_3$ ✓ ✓

(4)

16.3.2 Sulphuric acid / H_2SO_4 / Phosphoric acid / H_3PO_4. ✓ (1)

16.4



(5)

16.5 $2C_4H_{10}$ ✓ + $13O_2 \rightarrow 8CO_2 + 10H_2O$ ✓ Balancing ✓ (3)

[17]

QUESTION 17

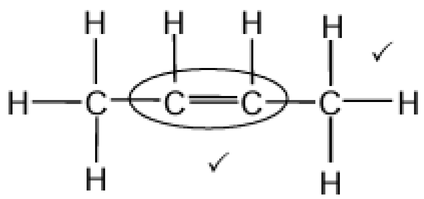
17.1.1 2-bromobutane✓✓ (2)

17.1.2 NaBr/Sodium bromide✓ (1)

17.1.3 Addition✓ (1)
Hydrohalogenation/Hydrobromination

17.1.4 Concentrated) sulphuric acid/ H_2SO_4/Phosphoric acid/H_3PO_4✓ (1)

17.1.5



Marking criteria:

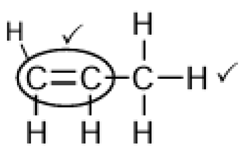
- Correct functional group ✓
- Whole structure correct ✓

(2)

17.1.6 Concentrated strong base/ NaOH/KOH/LiOH ✓ (1)

17.2.1 Decolourisation/colour fades/becomes lighter in colour/colourless✓ (1)

17.2.2



Marking criteria:

- Correct functional group ✓
- Whole structure correct✓

(2)

17.2.3 **X** / C_3H_6 / Propene ✓

- **X** is unsaturated/has a double bond/is an alkene. ✓
- **X** undergoes addition.✓

OR

- Alkenes are more reactive than alkanes/Unsaturated compounds react faster than saturated compounds.
- Addition reaction is faster than substitution. (3)
- Addition reaction does not need UV/light.

[15]

QUESTION 18

18.1 A chemical process in which longer chain hydrocarbon molecules are broken down to shorter, more useful molecules. ✓✓ (2)

18.2.1 Exothermic (1)

18.2.2 $C_3H_8 + 5O_2$ ✓ $\rightarrow 3CO_2$ ✓ $+ 4H_2O$ Balancing ✓ (3)

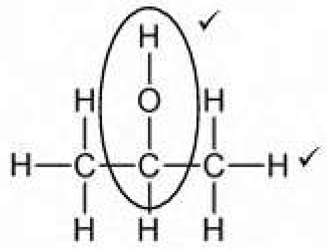
18.2.3 Carbon dioxide✓ (1)

18.3.1 Addition/hydrohalogenation/hydrobromination✓ (1)

18.3.2 No water/use unreactive solvent ✓ (1)

18.3.3 2-bromopropane ✓✓ (2)

18.4.1

	**Marking criteria:** • Functional group correct.✓ • Whole structural formula correct.✓

(2)

18.4.2 Substitution/hydrolysis ✓ (1)

18.5.1 Dehydration ✓ (1)

18.5.2 Propene/prop-1-ene ✓✓ (2)

[17]

QUESTION 19

19.1.1 X = 12✓

Y = 2 ✓

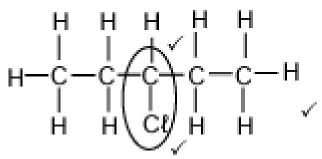
Z = 4 ✓ (3)

19.1.2 $2C_6H_{14} + 19O_2$ ✓ $\rightarrow 12CO_2 + 14H_2O$✓ Balancing ✓ (3)

19.2.1 Compounds with the same molecular formula, but different positions of the side chain / substituents / functional groups on the parent chain. ✓✓ (2)

19.2.2 Addition/hydrohalogenation/hydrochlorination ✓ (1)

19.2.3

	**Marking criteria:** • Chlorine atom bonded to any C-atom. ✓ • Correct functional group on third C-atom. ✓ • Whole structure correct. ✓

(3)

19.2.4 HCl ✓ (1)

19.2.5 (Concentrated/ conc.) H_2SO_4 / sulphuric acid / H_3PO_4 / phosphoric acid ✓ (1)

19.2.6 Concentrated strong base✓ **OR** Concentrated NaOH / KOH / LiOH (1)

19.2.7 • Elimination ✓

• Dehydrohalogenation/dehydrochlorination ✓ (2)

[17]

QUESTION 20

20.1.1 Heat/sunlight/ultraviolet light/radiation/light✓ (1)

20.1.2 HBr/hydrogen bromide✓ (1)

20.1.3 Hydrolysis✓ (1)

20.1.4 H_2O/water✓ (1)

NaOH/KOH/LiOH/sodium hydroxide/potassium hydroxide/lithium hydroxide

20.1.5 2-bromopropane ✓✓ (2)

20.2

+ NaOH in ethanol

CH_3CH_2Cl + conc. NaOH ✓ $\xrightarrow{\Delta}$ ✓ CH_2CH_2 ✓ + NaCl ✓ + H_2O ✓

$CH_2CH_2 + H_2$ ✓ $\xrightarrow{Pt}$ ✓ CH_3CH_3 ✓ (8)

[14]

QEUSTION 21

21.1..1 Dehydrohalogenation/elimination/dehydrobromination✓ (1)

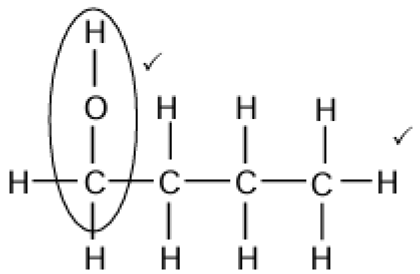
21.1.2 2-methylbut-2-ene ✓✓ (2)

21.1.3 Water/H_2O✓ (1)

21.1.4 Heat✓

Sulphuric acid(concentrated) as a catalyst✓ (2)

21.1.5



Marking criteria:
- Functional group correct.✓
- Whole structural formula correct.✓

(2)

21.2.1 Catalyst/Lowers the activation energy./Increases the rate of the reaction.✓ (1)

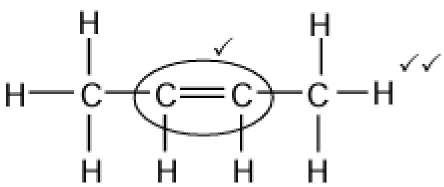
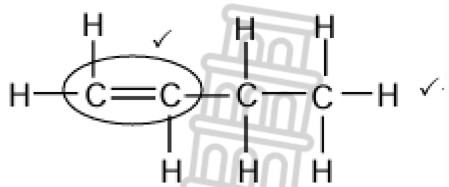
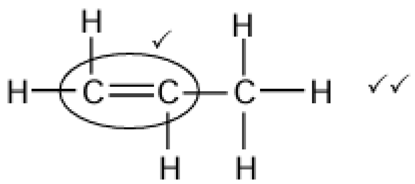
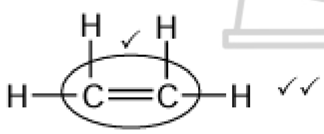
21.2.2 The bromine water/Br_2/solution decolourises.✓

Bromine water/Br_2/solution changes from brown/reddish to colourless. (1)

21.2.3 Addition/halogenation/bromination✓ (1)

21.2.4 C_2H_6 ✓✓✓ OR C_4H_{10} OR C_6H_{14} (3)

21.2.5

IF C_2H_6 in QUESTION 21.2.4	
 **OR/*OF*** 	
IF C_4H_{10} in QUESTION 21.2.4	**IF C_6H_{14} in QUESTION 21.2.4**
	

(3)

[17]

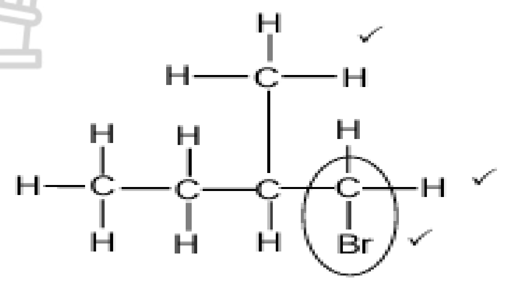
QUESTION 22

22.1.1 Substitution✓ (1)

22.1.2 Primary (alcohol)✓

- The C-atom bonded to the hydroxyl/-OH is bonded to (only) one other C atom.✓ (2)

22.1.3



Marking criteria:
- Four C atoms in longest chain.✓
- One methyl substituent on C2. ✓
- Bromo substituent on C1.✓

(3)

22.1.4 Elimination/dehydrohalogenation/dehydrobromination ✓ (1)

22.1.5 Alkenes✓ (1)

22.1.6 Addition✓ (1)

22.1.7 2-bromo-2-methylbutane✓✓ (2)

22.2.1 $CH_3CHCHCH_3$ ✓ + H_2 ✓ $\xrightarrow{\text{Pt/Ni/Pd ✓}}$ $CH_3CH_2CH_2CH_3$ ✓

22.2.2 Elimination/Cracking✓ (1)

22.2.3 Propene/prop-1-ene✓✓ (2)

22.2.4 CH_3CHCH_2 ✓ + Br_2 ✓ $\longrightarrow$ $CH_3CHBrCH_2Br$ ✓

(3)

[21]

DOPPLER EFFECT SOLUTIONS

QUESTION 1

1.1 A✓✓ (2)

1.2 B✓✓ (2)

1.3 A✓✓ (2)

1.4 D✓✓ (2)

1.5 C✓✓ (2)

[10]

QUESTION 2

2.1 The change in frequency (or pitch) of the sound detected by a listener, because the sound source and the listener have different velocities relative to the medium of sound propagation.✓✓ (2)

2.2 $\lambda = \frac{v}{f}$✓

$\lambda = \frac{340}{5000}$✓ (3)

$\lambda = 0,068\ m$✓

2.3 Shift 1

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$f_L = \frac{340 - v_o}{340}(5\ 000)$✓

Shift 2

5104✓ $= (\frac{340}{340 + v_o})(\frac{340 - v_o}{340})$✓$(5\ 000)$

v = 3,50 m·s^{-1}.✓towards the source✓

(6)

2.4 To measure heartbeat of the unborn foetus in the womb.✓
To measure blood flow rate.✓ (2)

[13]

QUESTION 3

3.1 <u>The change in frequency (or pitch)</u> ✓ of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation.✓ (2)

3.2 $f_l = (\frac{v \pm v_L}{v \pm v_S}) f_s$ ✓

(910)✓$= \frac{(340+v_L)✓}{(340 - 0)✓}(850)$✓

V_L=24 m·s^{-1}.✓ (6)

3.3 Δx = vΔ t✓

Δx = 24✓

Δx =144 m✓ (3)

[11]

QUESTION 4

4.1 The change in frequency or pitch of sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation. ✓✓ (2)

4.2 AWAY FROM. ✓Detector records lower frequency. ✓ (2)

4.3 As the fire truck moves away from the detector, the wave fronts behind the truck become stretched out.✓The detector registers longer wavelength and lower frequency.✓ (3)

4.4.1 v = fλ ✓

340 ✓= f x 0,34

f = 1000 Hz ✓ (3)

4.4.2 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

$f_L = \frac{340 + 0✓}{340 + 20✓}(1000)$✓

$f_L = 944.44\ Hz$

v = fλ ✓

340 = 944.44 x λ

f = 1000 Hz ✓ (6)

4.5.1 Remains the same✓ (1)
4.5.2 Decreases✓ (1)
[18]

QUESTION 5

5.1 (Doppler) blood flow meter✓ (1)

5.2 $f_L = 954,3 + (954,3 \times \frac{3,25}{100})$✓ (2)

$f_L = 985,31$ Hz✓

5.3 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$✓

$985,31$✓$= \frac{v + 0}{v - 10,6}(954,3)$✓

$v = 336,80\ m \cdot s^{-1}$. (4)

5.4 Decreases ✓ (1)

5.5 For a constant velocity or speed of sound, if the frequency increases, then the wavelength decreases.✓✓ (2)
[10]

QUESTION 6

6.1 $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ ✓ **OR** $v = \frac{d}{t} = \frac{300}{10} = 30\ m \cdot s^{-1}$.

$300 = v_i(10)$

$v_i = 30\ m \cdot s^{-1}$.✓ (2)

6.2 The <u>change in frequency</u> (or pitch) (of the sound) detected by a <u>listener because the source and the listener have different velocities relative to the medium of sound propagation</u>.✓✓ (2)

6.3 Car/source (just) passes observer.✓ (1)

6.4 $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓

932✓$= \frac{340}{340-30}$✓f_s $\therefore f_s = 849,76$ Hz✓ (4)

6.5 **ANY TWO:** Doppler / Blood flow meter/Measuring the heartbeat of a foetus/Radar/Sonar/Used to determine whether stars are receding or approaching earth.✓✓ (2)
[11]

QUESTION 7

7.1 It is the (apparent) change in frequency (or pitch) of the sound (detected by a listener) ✓because the sound source and the listener have different velocities relative to the medium of sound propagation.✓ (2)

7.2.1 170 Hz✓ (1)

7.2.2 130 Hz✓ (1)

7.3 $f_l = (\frac{v \pm v_L}{v \pm v_S}) f_s$ ✓

$\frac{f_L}{f_s} = (\frac{v \pm v_L}{v \pm v_S})$ (6)

$170\checkmark = \dfrac{340+0}{340\text{-}V_s} \checkmark \times f_s \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$

$v_L = 45{,}33\ \text{m}\cdot\text{s}^{-1}$.

$130\checkmark = \frac{340-0}{340+v_s} \checkmark \times f_S \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$

$v_L = 45{,}33\ \text{m}\cdot\text{s}^{-1}.\checkmark$

[7]

QUESTION 8

8.1 Doppler effect ✓ <u>The change in frequency (or pitch)</u> ✓ of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation.✓ (3)

8.2 $f_l = (\frac{v \pm v_L}{v \pm v_S}) f_s \checkmark$

$\dfrac{110}{100} f_s \checkmark = (\dfrac{340}{340 - v_S}) \checkmark f_s \checkmark$

$v_s = 37{,}78\ \text{m}\cdot\text{s}^{-1}$ (5)

8.3 increases✓ (1)

[9]

QUESTION 9

9.1 Ambulance approaching :

$f_l = (\dfrac{v \pm v_L}{v \pm v_S}) f_s \checkmark$

$450\checkmark = \dfrac{340+0}{340\text{-}v_s} \checkmark f_S$

$450(340\text{-}v_S) = 340f_S$ ……………….(i)

Ambulance moving away

$385\checkmark = \dfrac{340\text{-}0}{340+v_s} \checkmark f_S$

$385(340+v_S) = 340f_S$ ……………….(ii)

$450(340\text{-}v_S) = 385(340+v_S)$

$v_S = 26.46\text{m}\cdot\text{s}^{-1}.\checkmark$ (6)

9.2 $450(340\text{-}v_S) = 340f_S \checkmark$ $385(340+v_S) = 340f_S$

$450(340\text{-}26.46) = 340f_S$ $385(340+26.46) = 340f_S$

$f_S = 414.98\ Hz\checkmark$ $f_S = 414.98\ Hz$ (2)

9.3 414.98 Hz✓ (1)

9.4 Blue shift-✓ phenomenon observed when light from an object decreased in wavelength (increase in frequency) and it occurs when light source moves towards an observer. ✓ (2)

[11]

QUESTION 10

10.1 The change in frequency (or pitch) of the sound detected by a listener, because the sound source and the listener have different velocities relative to the medium of sound propagation.✓✓ (2)

10.2.1 Velocity/speed/v_s of the ambulance/source ✓ (1)

10.2.2 **Frequency**/wavelength of the sound produced by the **ambulance siren** / f_s / **speed of sound**/ **density/temperature** of air/**detector/listener** is stationary ✓ (1)

10.3 As the velocity of the ambulance increases, the detected frequency decreases.✓✓

NOTE: If inversely proportional indicated. (2)

10.4 (Ambulance approaching)

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ ✓ Either

1298 ✓= $\frac{v}{v-20}(f_s)$ ✓Either

v= 1298(v-25)……………………………e.q.(1)

(Ambulance moving away)

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$

1115✓= $\frac{v}{v+25}(f_s)$

vf_S= 1115(v+25)…………………………e.q(2)

$e.q_1 = e.q_2$

1298(v-25)= 1115(v+25) ✓

V=329,64 m·s^{-1}.✓ (6)

[12]

QUESTION 11

11.1 Doppler effect.✓ It is the change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation.✓✓ (3)

11.2 $\lambda = \frac{v}{f}$

$f_L = \frac{340}{0,016}$✓

λ=21250 Hz

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$✓

21250✓ = $\frac{340+0}{340-V_B}(f_s)$✓

f_s =21250-62,5V_B

(4)

11.3 f_L =21 250-62,5V_B+850
=22 100-62,5V_B ✓ Any one

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$

$$29\,500 = \left(\frac{340}{340+v}\right)\left(\frac{340-v}{340}\right)(30\,000)$$

$(22100 - 62{,}5V_B)$ ✓ $= \frac{340+V_B}{340-0}$ ✓ (21250) ✓ $v = 6{,}8$ m·s^{-1}. ✓ (5)

[12]

PHOTOELECTRIC EFFECT

SOLUTIONS

QUESTION 1

1.1 D✓✓ (2)

1.2 A✓✓ (2)

1.3 C✓✓ (2)

1.4 A✓✓ (2)

1.5 A✓✓ (2)

[10]

QUESTION 2

2.1.1 The process whereby electrons are ejected from a (metal) surface when light of suitable frequency is incident on that surface. ✓✓ (2)

2.1.2 E = hf✓

= $(6{,}63 \times 10^{-34})(1{,}2 \times 10^{15})$ ✓

= $7{,}96 \times 10^{-19}$ J

No of e = No of photons

$= \frac{\text{Total energy of photons}}{\text{Energy of one photon}}$

$= \frac{1{,}75\times10^{-9}}{7{,}96\times10^{-19}}$ ✓

= $2{,}2 \times 10^9$ ✓ (4)

2.1.3 $E = W_o + E_{k(max)}$ ✓

$7{,}96 \times 10^{-19}$ ✓= $(6{,}63 \times 10^{-34})(9{,}09 \times 10^{14})$ ✓+ $(9{,}11 \times 10^{-31})v_{max}$✓

$v_{max} = 6{,}51 \times 10^5$ m·s^{-1}✓ (5)

2.2 An atom (electron) in higher (excited) energy state/level returns to a lower energy state/level. √

Energy is released as light (photons/frequencies of light are released). √ (2)

[14]

QUESTION 3

3.1 The process whereby electrons are ejected from a metal / surface when light (of suitable frequency) is incident on that surface. ✓✓ (2)

3.2 $7{,}48 \times 10^{-19}$ (J) ✓
$E = W_o + E_{k(max)}$ ($= W_o + ½mv^2{}_{max}$) ✓
When $E_{k(max)} = 0$ / $v = 0$ / $v^2 = 0$ / $E = W_o$ / W_o is the y-intercept✓ (3)

3.3 Mass (of photo-electron)/ m✓ (1)

3.4 $E = W_o + ½mv^2{}_{(max)}$ ✓
$11{,}98 \times 10^{-19}$ ✓$= 7{,}48 \times 10^{-19}$ ✓$+ ½(9{,}11 \times 10^{-31})\, v^2$ ✓
$v^2 = 0{,}9868 \times 10^{12}$
$X = 0{,}9868 \times 10^{12}$ ($m^2 \cdot s^{-2}$) ✓ (5)

3.5.1 Remains the same✓ (1)

3.5.2 Increases✓ (1)

[13]

QUESTION 4

4.1 The minimum frequency of light needed to eject electrons from a metal surface. ✓✓ (2)

4.2 Greater than✓✓ (2)

4.3 $E = W_o + E_{k(max)}$ ✓
$6{,}63 \times 10^{-34}$ fx ✓$= (6{,}63 \times 10^{-34})(10{,}40 \times 10^{14})$ ✓$+ 23{,}01 \times 10^{-19}$✓
$fx = 4{,}51 \times 10^{15}$ (Hz) ✓ (5)

4.4.1 No effect✓ (1)

4.4.2 Increases✓ (1)

4.4.3 No effect✓ (1)

[12]

QUESTION 5

5.1.1 Minimum energy needed for the electrons to be emitted from the metal surface✓✓ (2)

5.1.2 $1{,}045 \times 10^{15}$ Hz✓ (1)

5.1.3 Greater than✓
The maximum kinetic energy of electrons from sodium is smaller. ✓
E is constant / same frequency used / same light used ($E_{k(max)}$ is smaller; W_0 is larger). ✓ (3)

5.1.4 No ✓
The intensity of light does not have any effect on the ejection of electrons for metal M. ✓
The frequency of light has not changed / Energy of a photon has not changed. ✓ (3)

5.2.1 $E = hf$✓
$5{,}7 \times 10^{-19} - 1{,}3 \times 10^{-19}$ ✓$= (6{,}63 \times 10^{-34})\, f$ ✓
$f = 6{,}64 \times 10^{14}$ Hz✓ (4)

5.2.2 No ✓The energy does not correspond to any transition in this atom. ✓ (2)

[14]

QUESTION 6

6.1.1 $E=hf$ ✓

$E=(6.63\times10^{-34})(2.8\times10^{16})$ ✓ (4)

$E = 1.86 \times 10^{-17}\ J$ ✓

$E > W_0$ electrons will be ejected ✓

6.1.2 $F = \frac{kQ_1Q_2}{r^2}$ ✓

$F = \frac{(9\times10^{9})(5.4\times10^{-6})Q_2}{(0.1)^2}$ ✓✓

$Q_2 = 5.56\times10^{-9}\ C$

$n = \frac{Q}{e}$ ✓

$n = \frac{5.56\times10^{-9}}{1.6\times10^{-19}}$ ✓

$n = 3.47\times10^{10}$ electrons

number of photons $= n = 3.47\times10^{10}$ ✓ (6)

6.2.1 Absorption ✓ (1)

6.2.2 Continuous spectrum of white light, with dark lines replacing frequency. ✓✓ (2)

6.2.3 Diagram B ✓ (1)

[14]

	ELECTRIC CIRCUITS SOLUTIONS	
	MULTIPLE CHOICE	
1.1	C ✓✓	(2)
1.1	B ✓✓	(2)
1.3	C ✓✓	(2)
1.4	B ✓✓	(2)
1.5	D ✓✓	(2)
		[10]
	LONG QUESTIONS	
QUESTION 2		
2.1	Maximum/ Total energy provided / work done by a battery/ cell per unit/ coulomb of charge passing through it. ✓✓	(2)
2.2	$R = \frac{V}{I}$ ✓ $0.1 = \frac{V}{120}$ ✓ $V = 12\ V$ ✓	(3)
2.3.1	**OPTION 1** | **OPTION 2** | **OPTION 3**	

$P = I^2R$ ✓ $15 = I^2(12)$ ✓ $I = 1.12$ A ✓	$P = \frac{V^2}{R}$ $15 = \frac{V^2}{12}$ $V = 13.42\ V$ $P = VI$ ✓ $15 = (13.42)I$ ✓ $I = 1.12$ A ✓	$P = \frac{V^2}{R}$ $15 = \frac{V^2}{12}$ $V = 13.42$ V $V = IR$ ✓ $\underline{13.43 = I(12)}$ ✓ $I = 1.12$ A ✓

(3)

2.3.2 $A_1 = (1,12)(2)$

$= 2,24$ A ✓ (1)

2.4 $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R_P} = \frac{1}{12} + \frac{1}{12}$ ✓

$R_P = 6\ \Omega$

When S_1 closed and S_2 open

$\mathcal{E}_1 = I(R + r)$

$\mathcal{E}_1 = 2.24(6 + r)$ ✓

When S_1 open and S_2 closed

$\mathcal{E}_2 = I(R + r)$

$\mathcal{E}_2 = 120(0.1 + r)$ ✓

$\mathcal{E}_1 = \mathcal{E}_2$

$2.24(6 + r) = 120(0.1 + r)$ ✓

$r = 0.012\ \Omega$

$\mathcal{E} = I(R + r)$

$= 2,24(6 + 0,012)$

$= 13,46$ V ✓

(6)

2.5 Decrease✓

- Total/Load resistance decreases ✓
- Total current increases. ✓
- Vinternal increases✓
- Voltage across the light bulbs decreases / Vload decreases. ✓

(5)

QUESTION 3

3.1 The potential difference (voltage) across a conductor is directly proportional to the current in the conductor at constant temperature. ✓✓ (2)

3.2.2

OPTION 1	**OPTION 2**
$R = \frac{V}{I}$ $13 = \frac{V}{0.8}$ ✓ $V = 10.4$ V	$V_{13} = V_L$ $0.8(13)$ ✓ $= I_L\ (9.5)$ ✓ $I_L = 1.09\ A$ ✓

$R = \frac{V}{I_L}$

$9.5 = \frac{10.4}{I_L}$ ✓

$I_L = 1.09$ A ✓

(3)

3.2.2

OPTION 1	OPTION 2
$V_P = V_{9\Omega}$ 10.4 ✓ = $I_{9\Omega}$✓ $I_{9\Omega} = 1.16$ A	$I_{R_{9\Omega}} = I_{R_{13}}\left(\frac{R_{13}}{R_g}\right)$ ✓ $I_{R_{9\Omega}} = 0.8\left(\frac{13}{9}\right)$ ✓ $I_{9\Omega} = 1.16$ A

$$I_{total} = I_{13\Omega} + I_L + I_{9\Omega}$$

$I_{total} = 0.8+1.09+1.16$ ✓

$I_{total} = 3.05$ A ✓

(4)

3.2.3

OPTION 1	OPTION 2
ε = I(R + r) ✓ $24 = V_{ext} + 3.05(0.3)$ ✓ $V_{ext} = 23.09$ V $V_{ext} = V_P + V_R$ $23.09 = 10.40 + V_R$ ✓ $V_R = 12.69$ V $R = \frac{V}{I}$ $R = \frac{12.69}{3.05}$ ✓ R = 4.16 Ω ✓	ε = I(R + r) ✓ $24 = 3.05(R_{ext}+0.3)$ ✓ $R_{ext} = 7.57$ Ω $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $\frac{1}{R_P} = \frac{1}{13} + \frac{1}{9.5} + \frac{1}{9}$ ✓ $R_P = 3.41$ Ω $R_{ext} = R_P + R$ 7.57 = 3.41 + R ✓ R = 4.16 Ω ✓

(5)

3.3 Decrease ✓– no current is flowing ✓ (2)

3.4 Increases ✓

- V_R / IR decreases ✓thus
- V_{lost} / Ir decreases AND V_L increases ✓(and emf stays constant)
- R_L constant AND P α V^2 / $P = \frac{V^2}{R}$✓therefore L is brighter

OR

- R_L constant AND I_L increases AND P α I^2 / $P = I^2 R$ therefore L is brighter

(4)

[20]

QUESTION 4

4.1 The resistor / R_z is short circuited. ✓ (1)

4.2

OPTION 1	OPTION 2
$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $\frac{1}{R_P} = \frac{1}{R} + \frac{1}{2R}$ ✓	ε = I(R + r) ✓ $12 = 5.5(R_{ext}+0.2)$ ✓ $R_{ext} = 1.98$ Ω

	$R_P = 0.67R\ \Omega$ $\varepsilon = I(R + r)$ ✓ $12 = 5.5(0.67R + 0.2)$ ✓ $R = 2.97\ \Omega$ $R_Y = 5.95\ \Omega$ ✓	$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $\frac{1}{1.98} = \frac{1}{R} + \frac{1}{2R}$ ✓ $R = 2.97\ \Omega$ $R_Y = 5.95\ \Omega$ ✓	(5)
4.3	**OPTION 1** $\varepsilon = I(R + r)$ $\varepsilon = V_{ext} + Ir$ $12 = V_{ext} + 5,5(0,2)$ ✓ $V_{ext} = 10,9$ V $V_p = 10,9$ V $P = \frac{V^2}{R}$ ✓ $P = \frac{10.9^2}{2.97}$ ✓ $P = 40$ W ✓	**OPTION 2** $I_x = ⅔(5,5)$ ✓ $= 3,67$ A $P = I^2R$ ✓ $= (3,67)^2(2,97)$ ✓ $= 40$ W ✓	(4)
4.4	$R = \frac{V}{I}$ ✓ $5.95 = \frac{V}{1.3}$ ✓ $V = 7.72$ V ✓		(3)
4.5	**OPTION 1** $\varepsilon = I(R + r)$ ✓ $12 = 1,3(R_T + 0,2)$ ✓ $R_T = 9,03\ \Omega$ $R_T = R_Y + R_Z$ $9,03 = 5,95 + R_Z$ ✓ $R_Z = 3,08\ \Omega$	**OPTION 2** $\varepsilon = I(R + r)$ ✓ $IR = 12 - (1,3 \times 0,2)$ $IR = 11,74$ V $V_{ex} = V_{RY} + V_{RZ}$ $11,74 = 7,75 + V_{RZ}$ ✓ $V_{RZ} = 3,99$ V $V = IR$ $3,99 = 1,3R_Z$ ✓ $R_Z = 3,07\ \Omega$	
	$R_P = 0,67R$ $= (0,67)(2,97)$ $= 1,98\ \Omega$	$\varepsilon = I(R + r)$ $12 = 5,5(R + 0,2)$ $R_P = 1,98\ \Omega$	
	$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R_P} = \frac{1}{2.97} + \frac{1}{5.94}$ $R_P = 1.98\ \Omega$	$R_P = \frac{\text{Product}}{\text{sum}}$ $R_P = \frac{(2.97)(5.94)}{(2.97+5.94)}$ $R_P = 1.98\ \Omega$	
	$R_{ex} = \underline{3,08 + 1,98}$ ✓ $R_{ex} = 5,06\ \Omega$		
	$\varepsilon = I(R + r)$ $12 = I(5,06 + 0,2)$ ✓ $I = 2,28$ A ✓	$R = \frac{V}{I}$ $5.26 = \frac{12}{I}$ ✓	

	I=2.28 A ✓

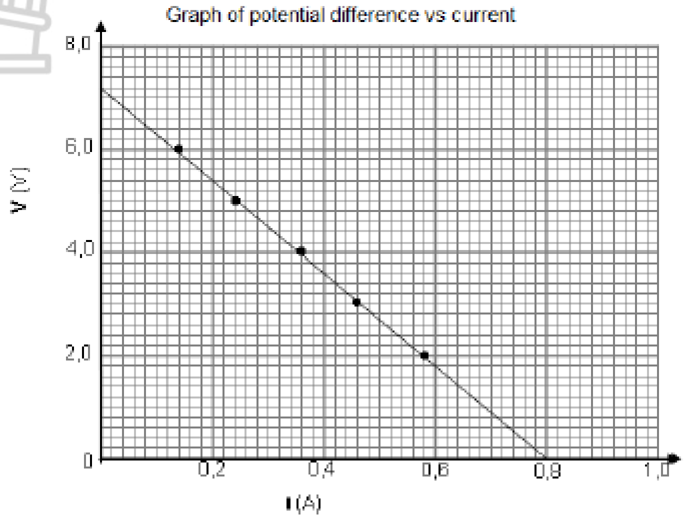
(6)

[19]

QUESTION 5

5.1.1 Keep the temperature (of battery) constant. ✓ (1)

5.1.2



Criteria for drawing line of best fit:	Marks
ALL points correctly plotted (at least 4 points)	✓✓
Correct line of best fit if all plotted points are used (at least 3 point)	✓

(3)

5.1.3 7,2 V ✓

(Accept any readings between 7,0 V and 7,4 V or the value of the y-intercept) (1)

5.1.4

$$\text{slope}=\frac{\Delta V}{\Delta I}$$

$$\text{slope}=\frac{0-7.2\ \checkmark}{0.8-0\ \checkmark}$$

slope= -9

slope= 9 Ω ✓ (3)

5.2.1

OPTION 1	**OPTION 2**
$P_{ave}= Fv_{ave}$ ✓ $P_{ave}= mgv_{ave}$ P_{ave} = (0.35)(9.8)(0.4) ✓ P_{ave} = 1.37 W ✓	$P=\frac{W_{nc}}{\Delta t}$ ✓ $P=\frac{\Delta E_K+\Delta E_P}{\Delta t}$ $P=\frac{0+(0.35)(9.8)(0.4-0)}{1}$ ✓ P_{ave} = 1.37 W ✓

(3)

5.2.2

OPTION 1	**OPTION 2**	
P = VI 1,37 = (3)I ✓	$P=\frac{V^2}{R}$	

I = 0,46 A $\varepsilon = V_{ext} + V_{int}$ $\varepsilon = V_T + V_X + V_{int}$ $12 = V_T + 3 + (0,2)(0,46)$ ✓ $V_T = 8,91$ V $V_T = IR_T$ $8,91 = (0,46)\ R_T$ ✓ $R_T = 19,37\ \Omega$ ✓	$1.37 = \frac{3^2}{R}$ ✓ R = 6.57 Ω P = VI 1,37 = (3)I ✓ I = 0,46 A $\varepsilon = I(R + r)$ $12 = 0,46(6,57 + R_T + 0,2)$ ✓ $R_T = 19,37\ \Omega$ ✓	

(4)

[15]

QUESTION 6

6.1 Temperature ✓ (1)

6.2.1 r = 3 Ω ✓✓ (2)

6.2.2

$\text{slope} = \frac{\Delta R}{\Delta \frac{1}{I}}$ ✓

$\varepsilon = \frac{7.5-(-3)}{1.5-0}$ ✓

$\varepsilon = -7$

$\varepsilon = 7$ V ✓

(3)

6.3.1

OPTION 1	**OPTION 2**
$I_{5.5\ \Omega} : I_{11\ \Omega}$ 2 : 1 $I_{5.5\ \Omega} = (0.2)(2)$ ✓✓ $I_{5.5\ \Omega} = 0.4$ A ✓	$R = \frac{V}{I}$ $11 = \frac{V}{0.2}$ V = 2.2 V ✓ $R = \frac{V}{I}$ $5.5 = \frac{2.2}{I}$ ✓ I = 0.4 A ✓

(3)

6.3.2

OPTION 1	**OPTION 2**
$I_{tot} = (0,4 + 0,2)$ ✓ = 0,6 A $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ ✓ $\frac{1}{R_P} = \frac{1}{11} + \frac{1}{5.5}$ ✓ $R_P = 3.67\ \Omega$ $R_T = R_P + R_S$	$I_{tot} = (0,4 + 0,2)$ ✓ = 0,6 A $V_{ext} = V_{11\ \Omega} + V_{p_t}$ ✓ $= [I_{tot}\ (R_{11}) + 2,2]$ = 0,6 (11) ✓+ 2,2 = 8,8V ✓ $\varepsilon = V_{ext} + I_{tot}\ (r)$ ✓

	R_T= 3.67+ 11 ✓ R_T= 14.67 Ω ε = I(R + r) ✓ 9 = 0,6(14,67 +r) ✓ r = 0,33 Ω ✓ | 9 = 8,8 + 0,6r✓ r = 0,33 Ω ✓	(7)
6.3.3	Decrease ✓ The total resistance increases ✓	(2)
		[18]
	QUESTION 7	
7.1.1	From graph $\frac{R}{V}$ ✓	(1)
7.1.2	$\frac{1}{E}$ = 0.65 ✓ E = 1.54 V ✓	(2)
7.1.3	slope=$\frac{2-1 ✓}{4-1 ✓}$ $\frac{r}{E}=\frac{1}{3}$ $\frac{r}{1.54}=\frac{1}{3}$ r = 0.51 Ω ✓	(3)
7.2.1	Emf = I(R + r) ✓ 6 = I(9 + 1) ✓ ∴I = 0,6 A ✓	(3)
7.2.2	$P=I^2R$ ✓ $15=(0.6)^2R_1$ ✓ R_1=5 Ω R_P=9-5= 4 Ω ✓ $\frac{1}{R_P}=\frac{1}{R_1}+\frac{1}{R_2}$ $\frac{1}{4}=\frac{1}{R_2}+\frac{1}{4R_2}$ ✓ R_2= 5 Ω✓	(5)
7.3	W = VIΔt ✓ = (240)(9,5)(12)(60) ✓ = 1,64 x 10^6 J cost=$\frac{1,64 \times 10^6}{3.6 \times 10^6}$ ×1.47 ✓ = R 0.67 ✓	(4)
		[18]