KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

CURRICULUM GRADE 10 -12 DIRECTORATE

NCS (CAPS)
LEARNER SUPPORT DOCUMENT
GRADE 11
PHYSICAL SCIENCES

SOLUTIONS

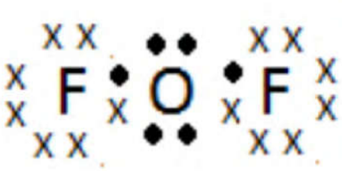
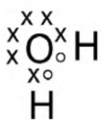
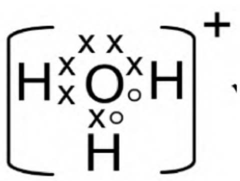
JUST IN TIME

2023

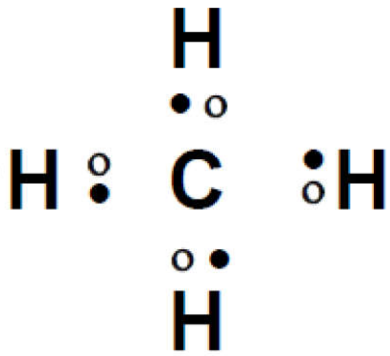
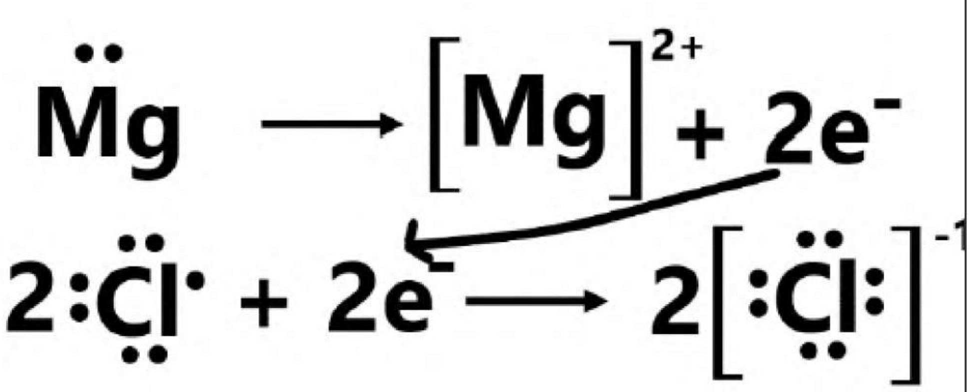
PREFACE

This support document serves to assist Physical Sciences learners on how to deal with curriculum gaps and learning losses because of the impact of COVID-19 in 2021. It also addresses the challenging topics in the Grade 11 curriculum in Term 1, 2,3 and Term 4.

Activities serve as a guide on how various topics are assessed at different cognitive levels and preparing learners for informal and formal tasks in Physical Sciences. It covers the following topics:

ATOMIC COMBINATIONS			
SOLUTIONS			
1.1	B✓✓		(2)
1.2	C✓✓		(2)
1.3	B✓✓		(2)
1.4	C✓✓		(2)
1.5	B✓✓		(2)
			[10]
QUESTION 2			
2.1	Electronegativity as a measure of the tendency of an atom in a molecule to attract bonding electrons✓✓		(2)
2.2	 ✓✓		(3)
2.3	ΔEN = (4,0 – 3,5) ✓ = 0,5✓ Weakly polar✓		(3)
	2.4.1	X-bond energy ✓and Y- bond length✓	(2)
	2.4.2	Bond energy of a compound is the energy needed to break one mole of its molecules into separate atoms. ✓✓	(2)
	2.4 3	More bonds✓, shorter bond length ✓and higher bond energy✓	(3)
			[15]
QUESTION 3			
3.1	The <u>sharing of electrons</u> ✓between (two) atoms (to form a molecule).✓		(2)
	3.2.1		(2)
	3.2.2	 ✓✓✓	(3)
	3.2.3	• One atom/ion must have an empty valence shell / orbital. ✓ • The other atom must have a lone pair of electrons. ✓	(2)

	3.3.1	A bond in which the electron density is shared equally between the two atoms✓✓	(2)
	3.3.2		
	a)	$\Delta EN = (3{,}5 - 2{,}5)$ ✓ = 1✓	(2)
	b)	$\Delta EN = (3{,}5 - 2{,}1)$ ✓ = 1,4✓	(2)
3.4	The bonds in both molecules are polar ✓due to the difference in electronegativities ✓between C and O and H and O. The shape of the H_2O <u>molecule is angular</u> ✓ and therefore the molecule is polar✓ because one side of the molecule can be positive and the other side negative. • The shape of the CO_2 molecule is <u>linear</u> ✓and thus it is non-polar ✓ because the charge distribution is symmetrical.		(6)
			[21]
QUESTION 4			
4.1	What is the relationship between bond energy and bond length? ✓✓		(2)
4.2	Size of atom✓ Bond order ✓		(2)
4.3	Energy absorbed = (4 x 413) ✓ + 2(1x498) ✓= 2648kj.mol^{-1} Energy released = (2x804) ✓ + (2x2x463) ✓ = 3460kj.mol^{-1} Since Energy released > Energy absorbed✓ Net energy is released in this reaction. ✓		(6)
4.4	540 kJ.mol^{-1}✓ The C=C✓ bond is stronger that C=C , but weaker than C≡ C✓ therefore energy required is greater than 348 kJ.mol^{-1} but less than 839 kJ.mol^{-1}✓		(4)
			[14]
QUESTION 5			
5.1			

	 ✓✓		(2)
5.2	covalent bond		(1)
	5.3.1	 ✓✓✓✓	(4)
	5.3.2	ΔEN = 3,0 – 1,2✓ = 1,8✓ Therefore magnesium chloride is ionic. ✓	(3)
			[10]

INTERMOLECULAR FORCES ACTIVITIES

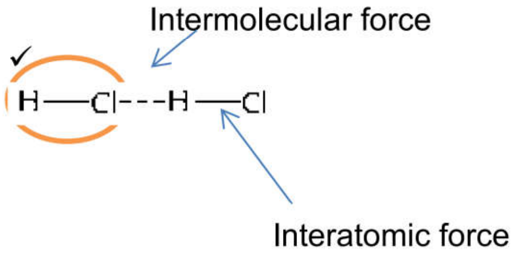
SOLUTIONS

QUESTION 1

1.1	Dipole-dipole forces ✓	(1)
1.2	Induced Dipole Forces✓	(1)
1.3	Ion dipole forces✓	(1)
1.4	Induced dipole forces✓	(1)

QUESTION 2

Given the following diagram:



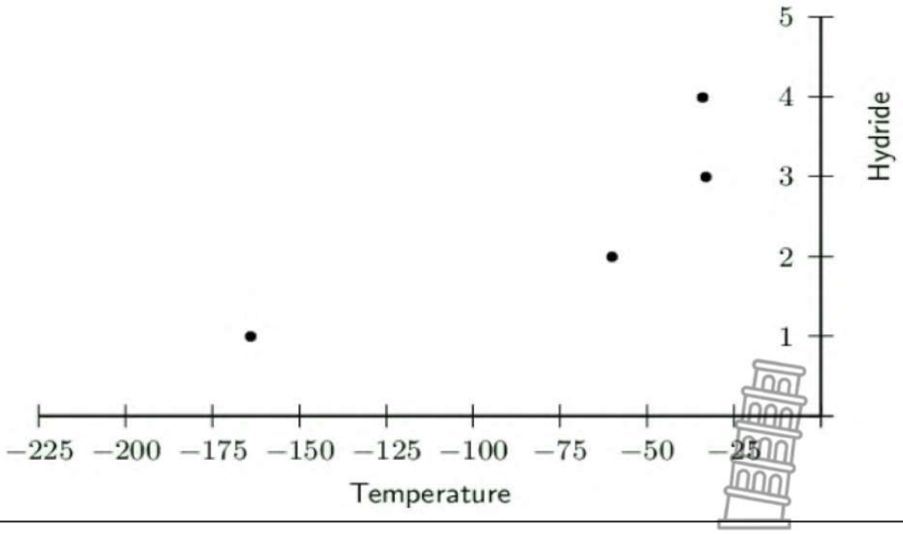
2.1	Hydrogen chloride✓	(2)
2.2	(In sketch)✓	(1)
2.3	(In sketch✓	(1)
		[4]

QUESTION 3

3.1 Complete the table below by placing each molecule next to the correct type of intermolecular force.

Type of force Molecules	**Type of force Molecules**
Ion-dipole Ion-induced-dipole	KI, NaCl, HF✓✓✓
Dipole-dipole (no hydrogen bonding)	HCl, NO✓✓
Dipole-dipole (hydrogen bonding)	H_2O, NH_3✓✓
Induced dipole	CO_2, I_2, Ar✓✓✓
Dipole-induced-dipole	SiO_2 in water✓

3.2.1	Water and Ammonia✓✓	(2)
3.2.2	Argon, Iodine and Carbon dioxide✓✓✓	(3)
		[16]

QUESTION 4		
4.1	NH_3 has hydrogen bonds which are much stronger than the induced dipole forces in F_2. In order for a liquid to boil the intermolecular forces must be broken and if the intermolecular forces are very strong then it will take a lot of energy to overcome these forces and so the boiling point will be higher. ✓✓	(2)
4.2	Water has strong intermolecular forces (hydrogen bonds) while carbon tetrachloride only has weaker induced dipole forces. (Carbon tetrachloride is non-polar). Substances with stronger intermolecular forces take longer to evaporate than substances with weaker intermolecular forces. ✓✓	(2)
4.3	Sodium chloride is likely to dissolve in methanol (CH_3OH) Sodium chloride is ionic. Methanol is polar. The type of intermolecular force that can exist when sodium chloride dissolves in methanol is ion-dipole forces. The formation of these forces helps to disrupt the ionic bonds in sodium chloride and so sodium chloride can dissolve in methanol. ✓✓	(2)
		[6]
QUESTION 5		
5.1	C HI and NH_3 only✓✓	(2)
5.2	Draw a graph to show the melting points of the hydrides. 	
	✓✓✓✓	(4)
5.3	There is a decrease in the temperature from the first hydride (number 4 on the graph) to the last one (number 1 on the graph). ✓The shape of the graph shows	(2)

	the decreasing intermolecular forces between the molecules in the compounds. ✓	
5.4.1	Water✓	(1)
5.4.2	Hydrogen bonding. This force occurs between the hydrogen atoms of one molecule and a high electronegativity atom of another molecule. The relatively positive hydrogen atom is attracted to the relatively negative atom (e.g., oxygen, nitrogen, fluorine). ✓✓✓	(3)
5.4.3	Hydrogen sulfide does not have hydrogen bonding since sulfur has a low electronegativity. This reduces the boiling point of hydrogen sulfide since it is easier to break the intermolecular forces between molecules of hydrogen sulfide. ✓✓✓	(3)
5.4.4	Thembile is correct.✓ Van der Waals forces✓ are the only forces that can exist with covalent molecules✓ and so including either ion-dipole or ion-induced dipole forces is not correct.	(3)
		[19]
QUESTION 6		
6.1	Bongani is correct.✓ NH_3 is polar. It has one lone pair of electrons and so is trigonal pyramidal. The three polar bonds do not cancel each other out since the molecule is not symmetrical. ✓This makes ammonia a dipole molecule. So, the type of intermolecular force that exists is dipole-dipole forces. ✓	(3)
6.2	Jason is correct. ✓Helium is a noble gas ✓and so exists as single atoms, not as a compound. Helium is non-polar and so has induced-dipole forces. ✓	(3)
6.3	KI(aq) has potassium and iodine ions in water. Water is a polar molecule.✓ So, the type of force must be ion-dipole. ✓	(2)
6.4	Materials expand on heating and contract on cooling. ✓If the power lines were strung tightly and did not sag, then every time the weather got cold the power lines would contract and break.✓	(2)
		[10]
QUESTION 7		
7.1	The temperature at which the vapour pressure of a substance equals atmospheric pressure. ✓✓	(2)
7.2	What is the relationship between intermolecular forces and boiling point? ✓✓	(2)
7.3	Glycerine,ΠIt has the highest boiling point✓✓	(2)
7.4	No, ✓ boiling point is only affected by the atmospheric pressure ✓	(2)
7.5	Avoid direct heating with open flameΠ Work in a well-ventilated room/use a fume cupboard ✓✓	(2)
7.6	Nail polish remover, ✓ lowest boiling point, weakest intermolecular forces, less energy is required to overcome intermolecular forces and can easily change to vapour✓✓	(3)
7.7	Sunflower oil has a large molecular mass ✓	(2)
		[15]

QUESTION 8		
8.1	Both water and ethanol have hydrogen which are the same in relative strength. ✓✓ Substances with comparable relative strength in intermolecular forces will dissolve. ✓	(3)
8.2	The intermolecular forces between the molecules of iodine and bromine are both London forces (Van der Waals forces/Induced dipole forces). ✓✓	(2)
8.3	• The intermolecular forces between phosphine molecules are dipole- dipole forces/Van der Waals forces. ✓ • The intermolecular forces between ammonia molecules are hydrogen bonds. ✓• The dipole-dipole forces are weaker than the hydrogen bonds. ✓ • Weaker forces will cause the molecules to evaporate faster/stronger forces will evaporate slower ✓	(4)
8.4	Bromine ✓	(1)
8.5	• The boiling point of bromine is lower than the other two liquids therefore it has weaker intermolecular forces. ✓ • If the intermolecular forces are weaker, the vapour pressure will be higher. ✓ OR • The boiling point of water and ethanol are higher than bromine, therefore it has stronger intermolecular forces. • If the intermolecular forces are stronger, the vapour pressure will be lower	(2)
		[12]
QUESTION 9		
9.1	• NH_3 has hydrogen bonds between the molecules ✓ • N_2 has London forces/induced dipole forces✓• NH_3 has stronger intermolecular forces than N_2 and therefore a higher boiling point than N_2 ✓ (Accept: more energy requires to overcome stronger forces of NH_3) **OR** • N_2 has weaker intermolecular forces than NH_3 and therefore a lower boiling point than NH_3 (Accept: less energy requires to overcome weaker forces of H_2)	(3)
9.2	H_2✓	(1)
9.3	H_2 and H N_2 both have weak London forces/induced dipole forces✓ • N_2 is a larger molecule/has a greater molecular mass/has a larger surface area than H_2✓ • and therefore, N_2 has stronger intermolecular forces. ✓ **OR** • H_2 is a smaller molecule/has a smaller molecular mass/has a smaller surface area than N_2	(3)

	• and therefore, H_2 has weaker intermolecular forces.	
9.4	H_2 ✓ It has the weakest intermolecular forces/London forces ✓ It has the lowest boiling point ✓ **OR** It has the weakest intermolecular forces/London forces Boiling point is inversely proportional to vapour pressure	(3)
		[10]
QUESTION 10		
10.1	The melting point is the temperature at which the solid and the liquid of a substance are in equilibrium✓✓	(2)
10.2	• HF has hydrogen bonds between molecules. ✓ • HCℓ has dipole-dipole forces✓ • Hydrogen bonds are stronger than dipole-dipole forces./*Intermolecular forces in HF stronger./ Intermolecular forces in HCℓ weaker.* ✓ • More energy is needed to overcome/break intermolecular forces. ✓	(4)
10.3	CS_2 ✓	(1)
10.4	CS_2 has a greater surface area/molecular mass/larger molecules (than CO_2). ✓ London forces increase with molecular mass/molecular size. ✓ More energy needed to break/overcome intermolecular forces✓	(3)
10.5	HCℓ ✓ Lowest boiling point. ✓	(2)
		[12]
QUESTION 11		
11.1	London forces (induced dipole-induced dipole) ✓	(1)
11.2	Although the molecules are non-polar, collisions cause a temporary shift in the electrons resulting in temporary/momentary ✓dipoles forming in the molecules. A force of attraction will form between the negative pole of one molecule and the positive pole of another molecule. ✓	(2)
11.2.1	Covalent bond (Intramolecular force). ✓	(1)
11.2.2	Van der Waals Forces (Dipole – dipole Intermolecular forces) ✓	(1)
11.3.1	Linear, not symmetrical✓	(1)
11.3.2	HF has a higher boiling point✓ than HCl due to the strong hydrogen bonding✓present in HF compared to the weaker dipole- dipole forces✓ in HCl	(3)
11.3.3	HCl, HBr, HI, HF ✓	(1)

		[10]

VECTORS IN TWO DIMENSIONS

SOLUTIONS

QUESTION 1

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

QUESTION 2

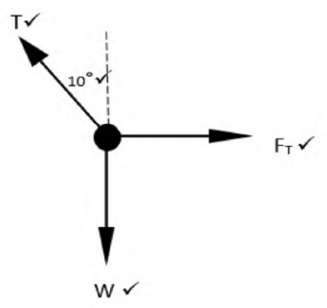
2.1 (2)

When a body is in equilibrium it will:
EITHER be at rest OR move with a constant linear velocity. ✓✓

OR

Net force is equal to zero and acceleration is equal to zero. ✓✓

2.2 (4)



Accepted Labels	
Fg/Fw	Fg/Fw/force of Earth on block/weight/6370N/ mg/gravitational force
F_T	F_T/Force applied by Thabo
T	T/ tension in the rope

ONE angle shown

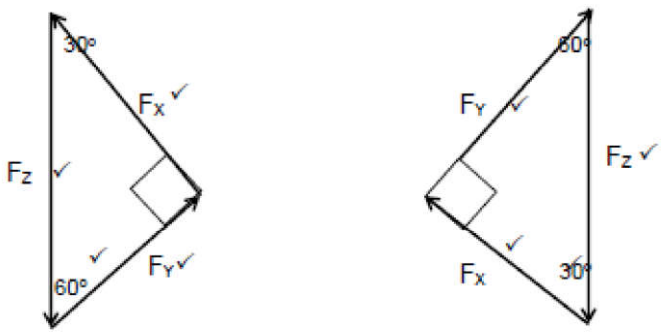
> **Note**
> One mark for correct arrow and label.
> If any other forces shown max. $^3/_4$
> If force body diagram max $^3/_4$

2.3 (3)

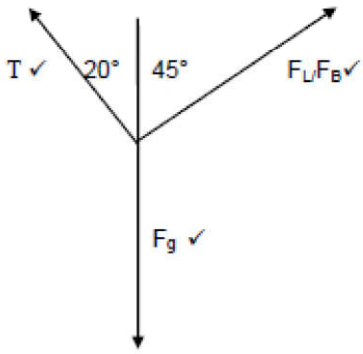
$\cos 10° = \frac{Fg}{T}$ ✓

$\cos 10° = \frac{650 \times 9.8}{T}$ ✓

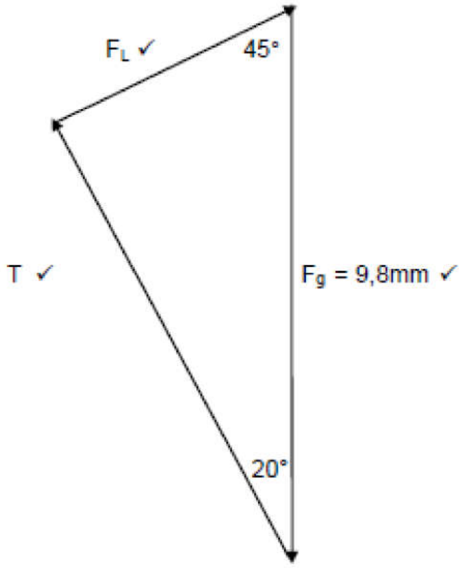
T = 6468.27 N ✓

2.4	$\cos 32° = \frac{Fg}{T}$ ✓ $\cos 32° = \frac{650 \times 9.8}{T}$ ✓ T = 7511.37 N ✓ Yes, the cable will snap. ✓	(4)
		[13]
QUESTION 3		
3.1	It is a single vector that can represent a number of vectors acting on an object in both magnitude and direction ✓✓	(2)
3.2	X : component: 8 N ✓ Y : component: -10 N ✓	(2)
3.3	$R_x = F_{1x} + F_{2x} + F_{3x} = 0 + 8 + (-6) = 2$ N ✓	(1)
3.4	$R_y = F_{1y} + F_{2y} + F_{3y} = 5 + (-10) + 0 = -5$ N ✓	(1)
3.5	$(R_{net})^2 = (R_x)^2 + (R_y)^2$ $= (2)^2 + (-5)^2$ ✓ $R_{NET} = \sqrt{29} = 5{,}39$ N ✓ $\tan\Theta = \frac{5}{2}$ ✓ Θ = 68,20° with respect to the positive x-axis ✓ or Θ = 21,80° with respect to the negative y-axis ✓	(4)
		[10]
QUESTION 4		
4.1	sum of two or more vectors ✓✓ or a single vector having the same effect as two or more vectors together ✓✓	(2)
4.2		(4)

Marking Rubric : Diagram	
Criteria	Mark allocation
Forces F_x, F_y, and F_z (W) correctly drawn and labelled in a closed triangle	3 × 1 = 3
Any two angles shown correctly	1
If no arrows shown, penalise once (max $^3/_4$)	

4.3	Z / F_z.✓ The lengths of the sides of a triangle represent the magnitude of the forces. Z is (the largest force) opposite the largest angle ✓ in the vector diagram. **OR** Z is the hypotenuse ✓ (of the triangle)/ it represents the weight)	(2)
4.4	$F_z = W = mg = 0.25 \times 9,8 = 2,45$ N ✓ $\sin 60^o = \frac{Fx}{Fz}$ ✓ OR $\cos 30^o = \frac{Fx}{Fz}$ $\sin 60^o = \frac{Fx}{2.45}$ ✓ OR $\cos 30^o = \frac{Fx}{2.45}$ $F_x = 2.122$ N ✓ $\cos 60^o = \frac{Fy}{Fz}$ OR $\sin 30^o = \frac{Fy}{Fz}$ $\cos 60^o = \frac{Fy}{2.45}$ OR $\sin 30^o = \frac{Fy}{2.45}$ $F_y = 1,225$ N ✓ **CRITERIA**: • Correctly calculating FZ / W. ✓ • Any correct formula involving a trigonometric ratio. ✓ • FX correctly computed. ✓ • FY correctly computed. ✓	(4)
		[12]
QUESTION 5		
5.1	The resultant of the forces is zero. ✓	(1)
5.2		(3)
5.3	$F_g = mg = (50)(9,8) = 490$ N ✓ SCALE 10 mm = 50 N $F_g = 490$ N = 98 mm (Accept 97 – 99 mm)	(8)

ACCEPTED LABELS	
F_g	Fw/W/Weight/mg/gravitational force/force due to gravity
T	F_T /Tension/Tension in rope
F_L /F_B	F_{legs} /Force of legs on wall



T = 76,5 × 5 = 382,5 N ✓ (Accept 76,4 – 76,6 mm)

F_L = 37,0 × 5 = 185 N ✓ (Accept 184,5 – 186,5 mm)

NOTES
• Mark awarded for correct label and direction. ✓
• ANY TWO angles indicated. ✓✓

CALCULATE instead of CONSTRUCTIONS max $\frac{5}{8}$

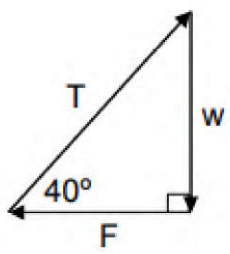
$\frac{\text{Fg}}{\sin 115°} = \frac{\text{FL}}{\sin 115°}$ $F_T = \frac{490✓\ sn\ 45°✓}{\sin 115°}$ = 382,50 N ✓

$\frac{\text{Fr}}{\sin\ 20°} = \frac{\text{Fg}}{\sin 115°}$ $F_R = \frac{490 \sin 20°}{\sin 115°}$ ✓ = 184,91 N ✓

[12]

QUESTION 6

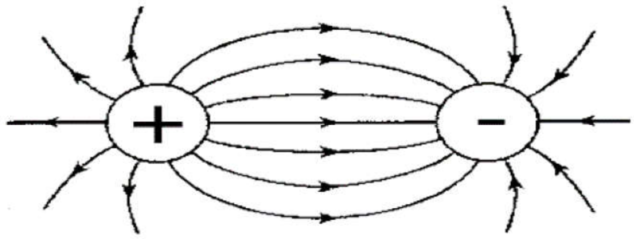
6.1	F_{net} = 0 N/ Object in equilibrium/Resultant is zero ✓✓	(2)
6.2	w = mg = (15)(9,8) ✓ = 147 N ✓	(2)
6.3		

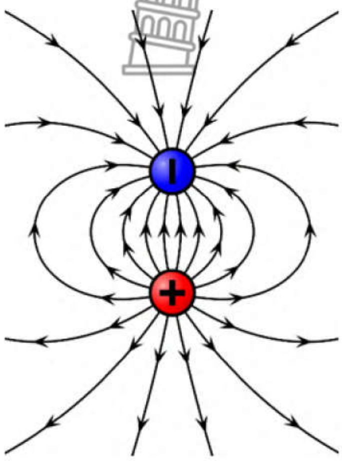
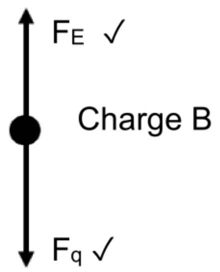
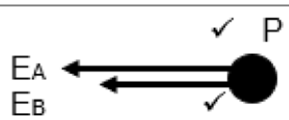


Accepted Labels		
W/F_g	weight/F_g/F	✓
F/F_A	Applied force/F/F_A	✓

	T	Tension/T	✓	
		Any angle correctly shown (40° or 50° or 90°)	✓	
		Triangle not closed	$\frac{3}{4}$	(4)
6.4	**OPTION 1** $T = \frac{W}{\sin 40}$ $= \frac{147}{\sin 40}$ ✓ = 228,69 N ✓	**OPTION 2** $T = \frac{W}{\cos 50}$ $= \frac{147}{\cos 50}$ ✓ = 228,69 N ✓		(2)
6.5	The two forces act on the same object (the billboard). ✓ (For the Newton's third law, the forces act on different objects.)			(1)
				[11]

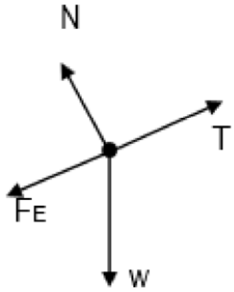
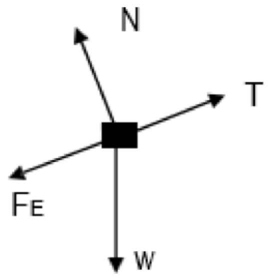
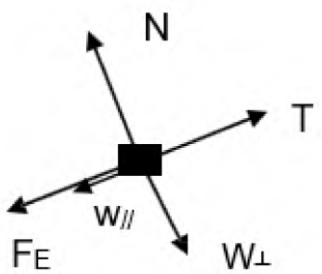
ELECTROSTATICS		
SOLUTIONS		
QUESTION 1 (MULTIPLE CHOICE QUESTIONS)		
1.1	B✓✓	(2)
1.2	C✓✓	(2)
1.3	A✓✓	(2)
		[6]
QUESTION 2		
2.1	The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them ✓✓	(2)
2.2	$F_J = \frac{kQ_JQ_L}{r^2}$ ✓ $F_J = \frac{(9 \times 10^9)(3 \times 10^{-6})(2 \times 10^{-6})}{(0,2)^2}$ ✓ ✓ F_J = 1,35 N right ✓	(4)
2.3.1	QL = -3×10^{-6} ✓	(1)
2.3.2	**OPTION 1** $n_e = \frac{Q_f - Q_i}{q_e}$ ✓ $n_e = \frac{-3\times10^{-6} - 2\times10^{-6}}{1.6\times10^{-19}}$ ✓ $n_e = 3.125 \times 10^{13}$ ✓ **OPTION 2** $n_e = \frac{Q_f - Q_i}{q_e}$ ✓ $n_e = \frac{-3 \times 10^{-6} + 8 \times 10^{-6}}{1,6 \times 10^{-19}}$ ✓ $n_e = 3,125 \times 10^{13}$ ✓	(3)

2.3.3	 **CRITERIA** | **Marks** Correct shape | ✓ Correct direction | ✓ Field lines not crossing each other | ✓	(3)
2.4	**OPTION 1** $E_J = \frac{kQ_J}{r^2}$ ✓ $= \frac{9\times10^9 \times 3\times10^{-6}}{(0,12)^2}$ ✓$= 1\ 875\ 000$ N•C^{-1} (West/Left) $E_M = \frac{kQ_M}{r^2} = \frac{9\times10^9 \times 3\times10^{-6}}{(0,08)^2}$ ✓ $= 4\ 218\ 750$ N•C^{-1} (West/Left) **Left positive** $E_{net} = E_J + E_M$✓ $E_{net} = (+1\ 875\ 000) + (+4\ 218\ 750)$ ✓(both substitutions) $E_{net} = 6\ 093\ 750$ N•C^{-1} West/Left ✓	
	OPTION 2 Enet = EJ + EM ✓ $= \frac{KQ_J}{r^2} + \frac{KQ_M}{r^2}$ ✓ ✓ one of the two $= \frac{(9\times10\ )\times(3\times10\ \ )}{(0,12)^2}$ ✓ $+ \frac{(9\times10\ )\times(3\times10\ \ )}{(0,08)^2}$ $= 6\ 093\ 750$ N•C^{-1} (West/Left) ✓	(6)
		[19]
QUESTION 3		

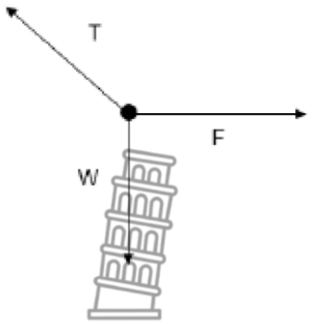
3.1	An Electric field as a region of space in which an electric charge experiences a force. ✓✓	(2)
3.2	$Q = nq_e$ ✓ $n = \frac{(-80\times10^{-9})}{(-1.6\times10^{-19})}$ ✓ $n = 5 \times 10^{11}$ electrons ✓	(3)
3.3	 ✓ shape between charges ✓ shape outside charges ✓ direction	(3)
3.4	 	(2)
3.5	$F_g = F_E$ $mg = \frac{kQ_AQ_B}{r^2}$ ✓ any formula $(0,01)(9,8)$ ✓ $= \frac{(9\times10^9)(80\times10^{-9})(120\times10^{-9})}{r^2}$ ✓ $r = 0,0296$ m ✓ ACCEPT: r = 0,03 m	(4)
3.6	 	(2)
3.7	(a) $E_A = kQ/r^2$ ✓ $= (9\times10^9)(80\times10^{-9}) / (x - 0,05)^2$ ✓ (b) $E_B = kQ/r^2$ $= (9\times10^9)(120\times10^{-9}) / (0,05)^2$ ✓ $= 432\ 000$ N·C^{-1} (c) $E_{NET} = E_A + E_B$	(6)

	$54{,}45\times10^4$ ✓ = $720/(x - 0{,}05)^2$ + ✓ 432 000 x = 0,13 m ✓	
		(22)
QUESTION 4		
4.1.1	Distance (between the point charges)/medium/air ✓	(1)
4.1.2	The electrostatic force is directly proportional to the product of charges. ✓	(1)
4.1.3	$\text{gradient} = \frac{\Delta F}{\Delta Q^2}$ $= \frac{(4-3)\times10^{12}}{\Delta Q^2}$ ✓ **NOTE:** acceptany value from the graph $= \frac{1\times10^{12}}{1}$ ✓ $= 1\times10^{12}\,\text{N}\cdot\text{C}^{-2}$ ✓	(3)
4.1.4	$F = \frac{KQ_1Q_2}{r^2}$ ✓ $\frac{F}{Q^2} = \frac{K}{r^2}$ 1×10^{12} ✓ $= \frac{9\times10^9}{r^2}$ ✓ $r^2 = 9\times10^{-3}$ r = 0,09487 m (0,095 m) ✓ NOTE: If $F = \frac{KQ^2}{r^2}$ is used, then maximum: $^3/_4$	(4)
4.2.1	A region in space in which an electric charge experiences a force. ✓✓	(2)
4.2.2	$E = \frac{KQ}{r^2}$ ✓ $E_{net},p = 0$ $\frac{KQ_1}{r^2}$ ✓ $= \frac{KQ_2}{r^2}$ $\frac{(9\times10^9)(8\times10^{-6})}{(0{,}4-d)^2} = \frac{(9\times10^9)(2\times10^{-6})}{d^2}$ ✓ ACCEPT: If 10^{-6} is omitted since it appears on both sides. $\frac{d^2}{(0{,}4-d)^2} = \frac{(2\times10^{-6})}{(8\times10^{-6})}$ $= 0{,}25$ $\frac{d}{(0{,}4-d)} = 0{,}5$ $d = 0{,}1333$ m ∴ the distance is 0,1333 m ✓	(4)

4.2.3	**OPTION 1** $Q_{new} = \frac{Q_1 + Q_2}{2}$ $= \frac{8\times10^{-6}+2\times10^{-6}}{2}$ ✓ $= 5 \times 10^{-6}$C $n = \frac{Q}{e}$✓ $n = \frac{5\times10^{-6}-8\times10^{-6}}{-1,6\times10^{-19}}$✓ $n = 1,875 \times 10^{13}$electrons✓	**OPTION 2** $Q_{new} = \frac{Q_1 + Q_2}{2}$ $= \frac{8\times10^{-6}+2\times10^{-6}}{2}$✓ $= 5 \times 10^{-6}$C $n = \frac{Q}{e}$✓ $n = \frac{5\times10^{-6}-2\times10^{-6}}{1,6\times10^{-19}}$ ✓ $n = 1,875 \times 10^{13}$electrons✓	(4)
			(19)
QUESTION 5			
5.1	$n = \frac{Q}{q_e}$ ✓ $n = \frac{-15 \times 10^{-9}}{-1,6 \times 10^{-19}}$ ✓ $= 2.5 \times 10^{13}$ electrons ✓		(3)
5.2	$F_{AB} = \frac{kQ_1Q_2}{r^2}$ ✓ $F_{AB} = \frac{(9 \times 10^9)(4 \times 10^{-6})(3 \times 10^{-6})}{(0,2)^2}$ ✓ $= 2.70$ N ✓		(3)
5.3	Electric field is a region in space in which an electric charge experiences a electric force. ✓ ✓		(2)
5.4	$E_{AM} = \frac{kQ}{r^2}$ ✓ $E_{AM} = \frac{(9 \times 10^9)(4 \times 10^{-6})}{(0,3)^2}$ ✓ $= 4,0 \times 10^5 N \cdot C^{-1}$ left $E_{BM} = \frac{kQ}{r^2}$ $E_{BM} = \frac{(9 \times 10^9)(3 \times 10^{-6})}{(0,1)^2}$ ✓ $= 2,7 \times 10^6 N \cdot C^{-1}$right $E_{net} = E_{BM} + E_{AM}$ $= 2.7 \times 10^6 + (-4.0 \times 10^5)$ ✓ $= 2.3 \times 10^6$ N.C^{-1} right ✓		(5)

5.5	Positive✓	(1)
5.6	$(F_{net})^2 = (F_{AD})^2 + (F_{AB})^2$ $(7.69)^2 = (F_{AD})^2 + (2.7)^2$ ✓ $F_{AD} = 7.2$ N $F_{AD} = \frac{kQ_1Q_2}{r^2}$ $7{,}2 = \frac{(9\times10^9)(4\times10^{-6})(Q)}{0.15^2}$ ✓ $Q_D = 4{,}5\times10^{-6}$ C ✓	(3)
		(17)
QUESTION 6		
6.1	The magnitude of the electrostatic force exerted by one point charge on another point charge is directly proportional to the product of the (magnitudes) of the charges ✓ and inversely proportional to the square of the distance between them. ✓	(2)
6.2	$F = \frac{KQ_1Q_1}{r^2}$ ✓ $1{,}2\times10^{-3} = \frac{(9\times10^9)(6\times10^{-9})(5\times10^{-9})}{r^2}$ ✓ $r = 0{,}015$ m (0.02 m) ✓ **Note:** • 1 mark for all substitutions/ • If negative charge substituted Max: 2/3	(3)
6.4	 **ACCEPT**  **ACCEPT**  **Accept the following symbols:** N ✓ — F_N / Normal /Normal force W ✓ — F_g / Weight /$F_{\text{earth on sphere}}$ / 0.098 N /gravitational force	(4)

	T ✓	Tension / F_T	
	F_E ✓	F_R / F / Electrostatic force	
	Notes • Mark awarded for label <u>and</u> arrow • Do not penalise for length of arrows since drawing is not to scale. • Any other additional force(s) *Max*: $^3/_4$ • If force(s) do not make contact with body Max: $^3/_4$ • If W is not shown but $w_{//}$ and $w_{\perp}$ are shown give 1 mark for both.		
6.4.1	$F_{net} = ma$ $T - F_E - w_{\parallel} = ma$ ✓Any one $T - F_E - w_{\parallel} = 0$ $T - \underline{1,2 \times 10^{-3}}$✓ $\underline{- (0,01)(9,8)\sin 25°}$✓ = 0 T = 0,04 N ✓ (0,0426 N) **OR** $F_{net} = ma$ ✓ $T - F_E - w_{\parallel} = ma$ $T - F_E - w_{\parallel} = 0$ $T - \underline{1,2 \times 10^{-3}}$ ✓ $\underline{- (0,01)(9,8)\cos 65°}$✓ = 0 T = 0,04 N✓ (0,0426 N)		(4)
6.4.2	$E = k\frac{Q}{r^2}$ $E_{net} = E_R + E_S$ } ✓ anyone $E_{net} = E_R + (-E_S)$ $E_{net} = \frac{KQ_R}{r^2} + \frac{KQ_S}{r^2}$ $E_{net} = \frac{(9\times10^9)(5\times10^{-9})}{(0.015+0.03)^2} + \frac{(9\times10^9)(6\times10^{-9}}{(0.03)^2}$ $E_{net} = -37\ 777.78$ $E_{net} = 37\ 777.78$ N·C^{-1} ✓ (3.78× 10^4) down (the incline) / towards the charges		
			[18]
QUESTION 7			
7.1	The magnitude of the electrostatic force exerted by one point charge (Q1) on another point charge (Q2) is directly proportional to the product of the magnitudes of their charges✓✓		(2)
7.2	**Accept the following symbols**		(3)



T	Tension in the spring
F	Electrostatic force of repulsion
W	F_g / mg / gravitation force

7.3	W = mg = 0.0009 × 9.8✓ = 0.0088 N Tan 45 = $\frac{F}{0.0088}$✓ F = 0.008 N repulsion to the right✓	(3)
7.4	$F = k\frac{Q_1Q_2}{r^2}$ ✓ $0.0088 = 9 \times 10^9 \frac{(Q)^2}{(0.04)^2}$✓ Q = 3.8 ×$10^{-8}$C✓	(3)
		[11]

ELECTRIC CIRCUITS		
SOLUTIONS		
QUESTION 1		
1.1	The potential difference across a conductor is directly proportional to the current in the conductor✓ at constant temperature. ✓ **OR** Provided temperature and other physical conditions are constant✓, the potential difference across a conductor is directly proportional to the current✓.	(2)
1.2	**OPTION 1** $V_{tot} = IR_{tot}$✓ $12 = (0,5)R_{tot}$ ✓ $\therefore R_{tot} = 24\ \Omega$ ✓ $\therefore R_X = (24 - 8)$ ✓$= 16\ \Omega$ ✓	
	OPTION 2 $V_8 = IR_{8\Omega}$ ✓ $= (0,5)(8)$ ✓ $= 4\ V$ $\therefore V_X = (12 - 4)$ ✓$= 8\ V$ $V_X = IR_x$ $8 = (0,5)(R_X)$ ✓ $\therefore R_X = 16\ \Omega$ ✓	
	OPTION 3 $V_8 = IR_{8\Omega}$ ✓	

	= 0,5 (8) ✓ = 4 V $\therefore V_X$ = (12 - 4) ✓= 8 V $V_X = \frac{Rx}{Rtot} Vtot$ $8 = \frac{Rx}{(8+Rx)} 12$ ✓ $\therefore R_X$ = 16 Ω ✓ **OR** $V_8 = IR_{8\Omega}$ ✓ = 0,5 (8) ✓ = 4 V $\therefore V_X$ = (12 - 4) ✓= 8 V $\frac{R_8}{Rx} = \frac{V_8}{Vx}$ $\therefore R_X = \frac{(8)(8)}{4}$ ✓ = 16 Ω ✓	(5)
1.2.1	12 V ✓	(1)
1.2.2	**OPTION 1** $V_4 = I_4 R_{4\Omega}$ ✓✓ $12 = I_4(4)$ ✓ $I_{4\Omega}$ = 3 A $V_X = I_{16\Omega}R$ $12 = I_{16\Omega}16$ ✓ $I_{16\Omega}$ = 0,75 A I_A = (3 + 0,75) ✓ = 3,75 A ✓	
	OPTION 2 $V_4 = I_4 R_{4\Omega}$ ✓ $12 = I_4(4)$ ✓ $I_{4\Omega}$ = 3 A $I_4R_4 = I_{16\Omega}R_{16\Omega}$ $(3)(4) = I_{16\Omega}(16)$ ✓ $I_{16\Omega}$ = 0,75 A	

	$I_A = (3 + 0{,}75)$ ✓ $= 3{,}75$ A ✓	
	OPTION 3 Combined resistance of the lower portion: $R = \frac{R16R4}{R16 + R4}$ ✓ $R = \frac{16 \times 4}{20}$ ✓ $= 3{,}2\ \Omega$ $V = I_AR$ 12 ✓ $= I_A(3{,}2)$ ✓ $I_A = 3{,}75$ A ✓	(5)
1.2.3	**OPTION 1** $V_{12} = \frac{R12}{Rtot}Vtot$ ✓ $V_{12} = \frac{12}{(8+12)}12$ ✓ $= 7{,}2$ V Energy $W = \frac{V2}{R}\Delta t$ ✓ $= \frac{(7.2)^2}{12}120$ ✓ $= 518{,}4$ J ✓	
	OPTION 2 $V_{8,12} = I(R_8 + R_{12})$ ✓ $12 = I(20)$ ✓ $I = 0{,}6$ A Energy $W = I^2R\Delta t$ ✓ $= (0{,}6)^2(12)(120)$ ✓ $= 518{,}4$ J ✓ **OR** $V_{8,12} = I(R_8 + R_{12})$ ✓ $12 = I(20)$ ✓ $I = 0{,}6$ A $V_{12} = IR_{12\Omega}$ $= 0{,}6(12)$ $= 7{,}2$ V Energy $W = VI\Delta t$ ✓	(5)

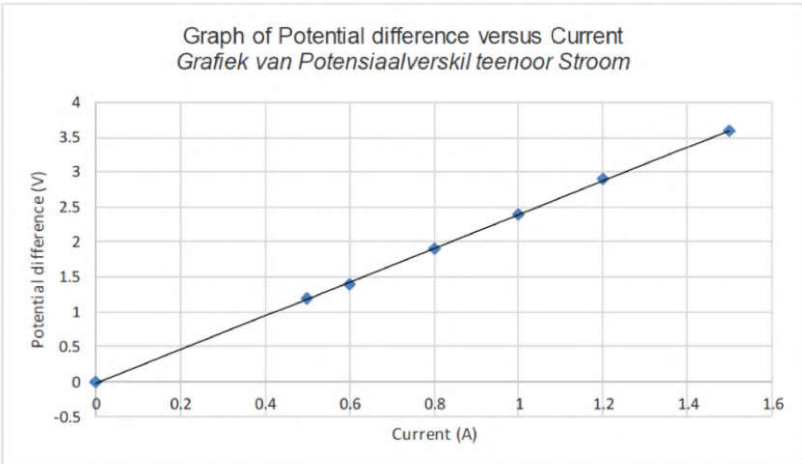
	= (7,2)(0,6)(120) ✓ = 518,4 J ✓	
		[18]
QUESTION 2		
2.1	The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature. ✓✓	(2)
2.2	More resistors connected in parallel. ✓ Therefor the effective resistance of the circuit decreases. ✓	(2)
2.3.1	Any set of values from the table can be used for example: $R = \frac{V}{I}$ ✓ $R = \frac{2,4}{4,8}$ ✓ R = 2 Ω ✓	(3)
2.3.2	**POSITIVE MARKING FROM QUESTION 2.3.1.** **OPTION 1** Switch 1 closed: R_{tot} = 3 + 2 ✓ R_{tot} = 5 Ω $V_{em}f = IR_{tot}$ ✓ V_{emf} = (2,4)(5) ✓ V_{emf} = 12 V ✓✓ **OPTION 2** Switches 1 and 2 closed: $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R} = \frac{1}{3} + \frac{1}{6}$ Rp = 2 Ω Rtot = 2 + 2 ✓ = 4 Ω Vemf = IR_{tot} ✓ = (3)(4) ✓ = 12 V ✓ **OPTION 3** 3 Switches 1, 2 and 3 closed $\frac{1}{R_1} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $= \frac{1}{3} + \frac{1}{6} + \frac{1}{4}$ R_p = 1,33 Ω R_{tot} = 1,33 + 2 ✓ = 3,33 Ω	

	$V_{emf} = IR_{tot}$ ✓ $= (3,6)(3,33)$ ✓ $= 12$ V ✓	(4)
		[11]
QUESTION 3		
3.1	**OPTION 1** $\frac{1}{R_p} = \frac{1}{R1} + \frac{1}{R2}$ ✓ $\frac{1}{4,8} = \frac{1}{4R} + \frac{1}{6R}$ ✓ R = 2 Ω ✓	
	OPTION 2 $R = \frac{R_1 R_2}{R_1 + R_2}$ ✓ $R = \frac{4R \: x \: 6R}{4R+6R}$ ✓ R = 2 Ω ✓	(3)
3.2	**POSITIVE MARKING FROM QUESTION 3.1**	
	OPTION 1 $V_{4R} = IR_{4R}$ = 1,8(4)(2) ✓ = 14,4 V $I_{6R} = \frac{14,4}{12}$ ✓ = 1,2 A $V_{2R} = IR$ ✓ = 1,2(4) ✓ = 4,8 V ✓	
	OPTION 2 $V_{4R} = IR_{4R}$ = 1,8(4)(2) ✓ = 14,4 V $I_T = \frac{V}{R_T}$ $I_T = \frac{14,4}{4,8}$ = 3 A $I_{2R} = 3 – 1,8$ ✓ = 1,2 A $V_{2R} = IR$ ✓ = 1,2(4) ✓	

	= 4,8 V ✓	
	$V_{4R} = IR_{4R}$ = 1,8(4)(2) ✓ = 14,4 V R : 2R : 3R 1 : 2 : 3 $V_R : V_{2R} : V_{3R}$ 1 : 2 : 3 ✓ $V_{2R} = \frac{2}{6} x\ 14{,}4$ ✓ V_{2R} = 4,8 V ✓ = 4,8 V ✓	(5)
3.3	**POSITIVE MARKING FROM 3.1 AND 3.2**	
	OPTION 1 $W = I^2R\Delta t$ ✓ $= 1{,}8^2(8)(120)$ ✓ = 1036,8 J ✓ **OPTION 2** W = VIΔt ✓ = (14,4)(1,8)(120) ✓ = 3110,4 J ✓ **OPTION 3** W2 = $\frac{V^2\Delta t}{R}$ ✓ W = $\frac{(14{,}4)^2\,(120)}{8}$ ✓ W = 3110,4 J ✓	(3)
3.4	Decrease ✓	(1)
3.5	The ammeter has such a <u>low resistance</u> ✓ It short circuits the parallel part and <u>all current flows through the ammeter</u>. ✓ **OR** The ammeter short circuits the resistors ✓ No current flows through resistor 2R ✓	(2)
		[14]
	QUESTION 4	

4.1.1	The inverse of the resistance **OR** 1/R✓	(1)
4.1.2	**OPTION 1/ *OPSIE 1*** Gradient/ *Gradiënt* = $\frac{\Delta I}{\Delta v}$ Gradient/ *Gradiënt* = $\frac{1,0-0,2}{3,0-0,6}$ ✓ Gradient/ *Gradiënt* = $\frac{1}{3}$ Gradient/ *Gradiënt* = $\frac{1}{R} = \frac{1}{3}$ ✓ R = 3 Ω ✓ **OPTION 2/ *OPSIE 2*** $R = \frac{V}{I}$ ✓ $R = \frac{3.0}{1,0}$ ✓ R = 3 Ω ✓	
4.2.1	**OPTION 1/ *OPSIE 1*** $R_1 = R_2$ $I_1 = I_2 = 1$ A ✓ $I = I_1 + I_2$ ✓ I = 1 + 1 = 2 A ✓ **OPTION 2/ *OPSIE 2*** $R = \frac{V}{I}$ R = 6 + 6 = 12 Ω $12 = \frac{V_p}{1}$ $V_p = 12$ V $12 = \frac{12}{I}$ I = 1 A ✓ $I = I_1 + I_2$ ✓ I = 1 + 1 = 2 A ✓	(3)
4.2.2	$R = \frac{V}{I}$ ✓ $12 = \frac{V_p}{1}$ ✓ $V_p = 12$ V $V = V_s + V_p$ $15 = V_s + 12$ ✓ $V_s = 3$ V $R = \frac{V}{I}$ $R = \frac{3}{2}$ ✓ R = 1,5 Ω ✓	
4.3	Increase, ✓ the total resistance decreases and the current increases. ✓	(2)

4.4	W = PΔt ✓ W = 1,5 x 3,5 ✓ W = 5,25 kWh Cost = 5,25 x 1,15 Cost = R6,04 ✓	(3)
		[17]
	QUESTION 5	
5.1	Ohm's law□□	(1)
5.2	Graph	



Marking criteria for graph ***Nasienkriteria vir grafiek***	
Axes with correct/appropriate scale *Asse met korrekte en toepaslike skaal*	✓
5 or more of the 6 coordinates correctly plotted (3–4 one mark only) *5 of meer van die 6 koördinate korrek gestip* *(3–4 slegs een punt)*	✓✓
Drawing a line of best fit *Teken 'n lyn van beste passing*	✓

(4)

5.3	Resistance of the parallel connection. □	(1)
5.4	Stays the same □	(1)
5.5	Increase □	(1)

5.6	**OPTION 1/*OPSIE 1*** $\frac{1}{R_p}=\frac{1}{R_1}+\frac{1}{R_2}$ $\frac{1}{Rp}=\frac{1}{R1}+\frac{1}{R2}$ ✓ $\frac{1}{R_p}=\frac{1}{4}+\frac{1}{6}$ $\frac{1}{Rp}=\frac{1}{4}+\frac{1}{6}$ ✓ ✓ $R_p = 2,4\ \Omega$ $R_{tot}=\frac{V}{I}$ $R_{tot}=\frac{V}{I}$ $R_{tot}=\frac{6}{0,8}$ ✓ $R_{tot}=\frac{6}{0,8}$ $R_{tot} = 7,5\ \Omega$ $R = R_{tot} - R_{par}$ $= 7,5 - 2,4$ ✓ $= 5,1\ \Omega$ ✓	
	OPTION 2/*OPSIE 2* $V_{tot} = 6$ V $V_R = V_{tot} - V_2$ $= 6 - 1,9$ ✓ $= 4,1$ V ✓ $R = \frac{V}{I}$ ✓ $R = \frac{4,1}{0,8}$ ✓ $R_{tot}=\frac{6}{0,8}$ $R = 5,1\ \Omega$ ✓	(5)
5.7	$V_R = 6 - 2,4 = 3,6$ V $W = \frac{V^2\Delta t}{R}$ ✓ $W = (3,6)(1)(10)$ $W = \frac{(3,6)^2\ 10}{2,4}$ ✓ $W = 36$ J ✓	(3)
		[16]
	QUESTION 6	
6.1	$P = \frac{W}{\Delta t}$ ✓ 2000 ✓ $= \frac{W}{(5 \times 3600)}$ ✓ $W = 36 \times 10^6$ J ✓	(4)
6.2	P = 2000 W = 2 kW	

	Δt = 5 hr x 30 days = 150 hours Cost = Power x Time X Price per unit = 2 x 150 x 80 ✓ = 24000 cents = R240 ✓	(2)
		[6]

ELECTROMAGNETISM		
SOLUTIONS		
QUESTION 4		
		[11]
4.1	The magnitude of the induced emf across the ends of a conductor is directly ✓ proportional to the rate of change in the magnetic flux linkage with the conductor ✓	(2)
4.2	$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ ✓ ✓ ✓ $3 = -200 \times 1{,}8 \times \Delta\Phi$ $\Delta\Phi = -\frac{3}{200 \times 1{,}8}$ $\Delta\Phi = -0{,}0083 \text{ Wb or } -8{,}33 \times 10^{-3} \text{ Wb}$ ✓	(4)
4.3	$\Delta\Phi = \Phi_f - \Phi_i$ $\Delta\Phi = BA\cos\theta_f - BA\cos\theta_i$ } ✓ any of the two ✓ ✓ -0,0083=$\underline{(2{,}4)(4{,}86 \times 10^{-3})\cos 90^0 - (2{,}4)(4{,}86 \times 10^{-3})\cos\theta_i}$ $\theta_i = 44{,}64^0$ $\Delta\theta = 90^0 - 44{,}64^0$ ✓ $= 45{,}36^0$ ✓	(5)
		[11]
QUESTION 5		
5.1	The magnitude of the induced emf across the ends of a conductor is directly proportional to the rate of change in the magnetic flux linkage with the conductor. ✓✓	(2)
5.2	$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ ✓	(3)

✓

	$7 = -400\frac{\Delta\Phi}{0,08}$ $\Delta\Phi = -\frac{7 \times 0,08}{400}$ ✓ $\Delta\Phi = -0,0014\ \text{Wb}$	
5.3	$\Delta\Phi = \Phi_f - \Phi_i$ $\Delta\Phi = \text{BAcos}45^0 - \text{BAcos}0^0$ } ✓ any of the two ✓ ✓ -0,0014 = $\underline{B \times 0,03^2 \times 0,707 - B \times 0,03^2 \times 1}$ $-0.0014 = -2,637 \times 10^{-4}\text{B}$ $\text{B} = \frac{0,0014}{2,637 \times 10^{-4}}$ $\text{B} = 5,31\ \text{T}$ ✓	(4)
5.4	INCREASE ✓	(1)
5.5	Emf is inversely proportional to time. ✓	(1)
5.6	SOUTH. ✓	(1)
5.7	FROM B TO A. ✓	(1)
		[13]
QUESTION 6		
6.1	$\Phi = \text{BAcos}\theta$ ✓ $\text{A} = \pi r^2$ $= \pi \times 0,04^2$ $= 0,005026\ \text{m}^2$ $\Phi = 3,2 \times 0,005026 \times \cos 0^0$ ✓ $= 0,0161\ \text{Wb}$ ✓	(3)
6.2	$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$	

	$\varepsilon = -N\frac{\Delta BA\cos\theta}{\Delta t}$ $\varepsilon = -N\left(\frac{BA\cos\theta_f - BA\cos\theta_i}{\Delta t}\right)$ ✓ any of the three ✓ ✓ $2,8 = -250\left(\frac{3,2\times 0,005026\cos 25^0 - 3,2\times 0,005026\cos 0^0}{\Delta t}\right)$ $2,8 = -250\left(\frac{-0,00150687}{\Delta t}\right)$ $\Delta t = \frac{250 \times 0,00150687}{2,8}$ $\Delta t = 0,135\ s$ ✓	(4)
6.3	Faraday's law of electromagnetic induction ✓ The magnitude of the induced emf across the ends of a conductor is directly proportional to the rate of change in the magnetic flux linkage with the conductor. ✓✓	(3)
6.4.1	SMALLER THAN. ✓	(1)
6.4.2	If $s = r, s^2 < \pi r^2$ $\therefore$ area of square < area of circle ✓ Emf is directly proportional to area. ✓ Therefore the emf will be smaller.	(2)
		[12]

QUANTITATIVE ASPECT OF CHEMICAL CHANGE			
SOLUTIONS			
QUESTION 1 – MULTIPLE CHOICE QUESTIONS			
1.1	B✓✓		(2)
1.2	D✓✓		(2)
1.3	B✓✓		(2)
1.4	A✓✓		(2)
			[8]
		QUESTION 1 - CONCENTRATION	
1.1.1		Number of moles of solute per unit volume of solvent. ✓✓	(2)
1.1.2		$C = \frac{m}{MV}$ ✓ $= \frac{8}{(40)✓(0,25)✓}$ = 0,80 mol·dm^{-3}✓	(4)
1.2.		$n(Na_3N) = \frac{55}{83✓}$ = 0,662 mol $n(Na_3N)$: N_2 2 : 1 ✓ $n(N_2) = \frac{1}{2} n(Na_2N)$ $= \frac{1}{2}(0,662)$ **ratio** = 0,331 mol $n = V/V_m$✓ 0,331 = V/22,4✓ V = 7,42 dm^3✓	(5)
			[11]
		QUESTION 2– EMPIRICAL FORMULA	
2.1.1		The simplest whole number ratio of atoms in a compound or molecules ✓✓	(2)
2.1.2		$n(C) = \frac{m}{M}$✓ $= \frac{54,55}{12}$ = 4,55 mol ✓ $n(H) = \frac{9,09}{1}$ = 9,01 mol ✓ $n(O) = \frac{36,36}{16}$ = 2,27 mol ✓ C : H : O $\frac{4,55}{2,27}$: $\frac{9,01}{2,27}$: $\frac{2,27}{2,27✓}$ 2 : 4 : 1 C_2H_4O ✓	(6)
2.1.3		Empirical formula mass (C_2H_4O) = 2(12) + 4(1) + 1(16) = 44 Factor = $\frac{88}{44}$ = 2 ✓ $C_4H_8O_2$ ✓	(2)

2.2.1		%H in H_2O = $\frac{2}{18} \times 100$ ✓ = 11,11% m(H) in H_2O = 11,11% of 19,35 g = 2,15 g ✓ % of C in CO_2 = $\frac{12}{44} \times 100$ = 27,27% ✓ m(C) in CO_2 = 27,27 of 47,1 g = 12,84 g – 12,85 g ✓ n(H) = $\frac{m}{M}$ = $\frac{2,15}{1}$ = 2,15 mol ✓ n(C) = $\frac{m}{M}$ = $\frac{12,84}{12}$ = 1,07 mol ✓ n(C) : n(H) 1,07 : 2,15 1 : 2 ✓ Empirical formular: CH_2 ✓	(8)
2.2.2		**POSITIVE MARKING FROM 2.2.1**	
		m(CH_2) = 1(12) + 2(1) = 14 $g.mol^{-1}$ M(true formula)/M(empirical formula) $\frac{28}{14}$ =2 ✓ C_2H_4 <u>x = 2 and y = 4</u> ✓	(2)
			[20]
		QUESTION 3 – COMPLEX STOCHIOMETRICAL CALCULATIONS	
3.1.		n(CaO) = $\frac{m}{M}$ ✓ = $\frac{11,76}{56}$ ✓= 0,21 mol n(CaO_3) = n(CaO) = 0,21 mol ✓ **(ratio)** m($CaCO_3$) = nM = (0,21)<u>(100)</u> ✓ = 21 g % purity = $\frac{m(pure\ compound}{m(impure\ sample)}$ × 100 80 ✓= $\frac{21}{m(impure\ sample}$ × 100 m(impure $CaCO_3$) = $\frac{(21)(100)}{80}$ ✓ = 26, 25 g ✓	(6)
3.2.1		n(K) = $\frac{m}{M}$ ✓ = $\frac{7,62}{39}$ ✓ = 0, 195 mol ✓	(3)

3.2.2		$n(S) = \frac{m}{M}$ $= \frac{4,34}{32}$ ✓ = 0,136 mol n(K) n(S) $= \frac{0,195}{2}$ $= \frac{0,136}{1}$ ✓ = 0,0975 = 0,136 ✓ Therefore potassium (K) is the limiting agent, ✓ since 0,0975 < 0,136 ✓	(5)
3.2.3		$n(K_2S) = \frac{1}{2}(0,195)$ ✓ = 0,0975 mol $m(K_2S)$ = nM = (0,0975)(110) ✓ = 10,725 g ✓	(3)
3.3.1		Magnesium, ✓ the mass of magnesium after 3 minutes✓/ at the end of reaction was zero	(2)
3.3.2		$C = \frac{n}{V}$ ✓ $0,36 = \frac{n}{0,5}$ ✓ n = 0,18 mol $n = \frac{m}{M}$ ✓ $= \frac{1,2}{24}$ ✓ = 0,05 mol n(Mg) : n(HCℓ) 1 : 2 n(HCℓ) = 2n(Mg) ✓ **ratio** = 2(0,05) = 0,1 mol n(HCℓ) left in the test tube = 0,18 – ✓ 0,1 = 0,08 mol ✓	(5)
3.4		$n(KI) = \frac{n}{M}$ ✓ $= \frac{0,75}{166}$ ✓ = 0,005 mol KI : PbI_2 2 : 1 $n(PbI_2) = \frac{1}{2}n(KI)$ $= \frac{1}{2}(0,005)$ ✓ ratio = 0,0025 mol $M(PbI_2)$ = nM = (0,0025)(461) ✓	

		$= 1{,}15$ g %yield = $\frac{actual\ mass}{theoritical\ mass} \times 100$ $= \frac{0{,}583}{1{,}15} \times 100$ ✓ $= 50{,}70$ % ✓	(6)
	3.5.1	H_2SO_4 ✓. It is completely used up ✓	(2)
	3.5.2	$\Delta m = 5g - 2g$ $= 3$ g ✓ $n(Zn) = \frac{m}{M} = \frac{3}{65}$ ✓ $= 0{,}046$ mol $n(H_2SO_4) = n(Zn)$ ✓ **ratio** $= 0{,}046$ mol $C = \frac{n}{v}$ ✓ $= \frac{0{,}046}{0{,}05}$ ✓ $= 0{,}92\ mol \cdot dm^{-3}$ ✓	(6)
	3.6.1	$2H_2O_2$ ✓ $\rightarrow 2H_2O + O_2$ ✓	(2)
	3.6.2	$n(O_2) = V/V_m$ ✓ $= 600 \times 10^{-3}/24{,}5$ ✓ $= 0{,}025$ mol. $H_2O_2 : O_2$ $2 : 1$ $n(H_2O_2) = \frac{1}{2}(O_2)$ $= \frac{1}{2}(0{,}025)$ ✓ **ratio** $= 0{,}05$ mol $n(H_2O_2) = \frac{m}{M}$ $0{,}05 = \frac{m}{34}$ ✓ $m = 1{,}70$ g ✓	(5)
			[33]

IDEAL GASES & THERMAL PROPERTIES

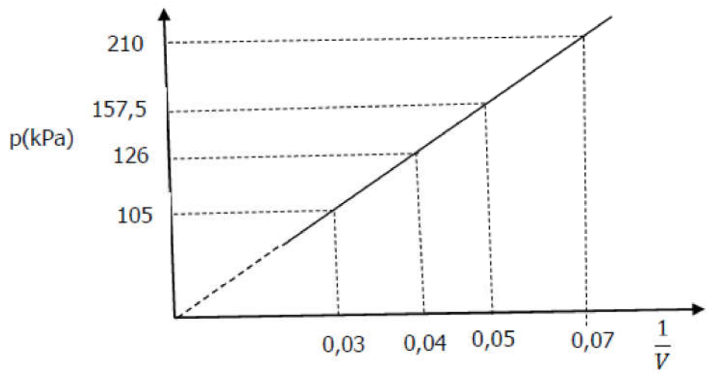
SOLUTIONS TO ACTIVITIES

QUESTION 1

1.1 D✓✓ (2)
1.2 B ✓✓ (2)
1.3 C✓✓ (2)
1.4 C✓✓ (2)
1.5 A✓✓ (2)
1.6 D✓✓ (2)
[12]

QUESTION 2

2.1 What is the relationship between pressure and volume? ✓✓ (2)
2.2 Independent: Pressure ✓
Dependent: volume ✓ (2)
2.3 Allow temperature to stabilise as the control variable. ✓✓ (2)
2.4 (i) 0,03 ✓
(ii) 0,04 ✓
(iii) 0,05 ✓
(iv) 0,07✓ (4)
2.5



Criteria	
Correct shape (straight line	✓
Both labels	✓
All points correct	✓ ✓ (two points: ONE mark)
Extrapolated to origin	✓

(5)

2.6 Volume is inversely proportional to the pressure provided the temperature remains constant ✓✓ (2)

[17]

QUESTION 3

$pV = nRT$ ✓

$(105000)(0,02)$□ $= n(8.31)(293)$ ✓

$n = 0,86$ mol

$n = m/M$ ✓

$0.86 = m/44$ ✓

$m = 37,84g$ ✓ (6)

QUESTION 4

4.1.1 P α 1/V OR v α 1/P ✓ (1)

4.1.2 Boyle's law ✓ (1)

4.1.3 As the volume of the container decreases, the number of collisions per unit area ✓on the walls of the container increases ✓ (2)

4.2 Mass ✓

Temperature ✓

- Wait a while after increasing the pressure before taking a volume reading. ✓
- Same mass of gas is trapped (in tube) /ensure that there is no leakage of gas ✓

(4)

4.3 30 cm^3 ✓✓ (2)

4.4 $P_1V_1 = P_2V_2$ ✓

$(120)(30)$ ✓ $= P_2(5)$ ✓

$P_2 = 720$ kPa ✓ (4)

4.5 High pressures ✓

Low temperatures ✓ (2)

[16]

QUESTION 5

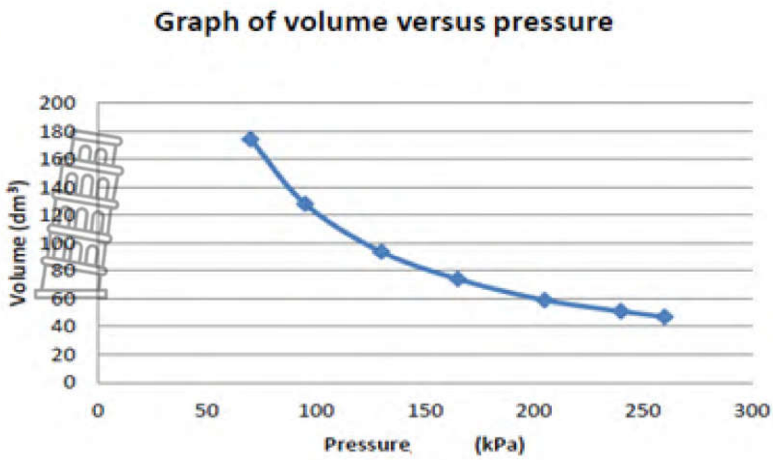
5.1 Boyle's law ✓ (1)

5.2 If the pressure of and enclosed gas increases the volume will decrease at constant temperature. ✓✓

OR

The pressure of an enclosed gas is inversely proportional to the volume it occupies if the temperature is kept constant. ✓✓ (2)

5.3



Criteria	
Correct shape (straight line	✓
Both labels	✓
Atleast 6 points correct	✓

(3)

5.4 $P_1V_1 = P_2V_2$ ✓

$\underline{70(174) = (300)V_2}$ ✓

$V_2 = 40,6\ dm^3$ ✓ (3)

5.5 At high pressure, a gas starts to deviate from ideal gas behaviour ✓ because the volume of the molecules of a gas and the intermolecular forces start to influence the measured value, causing it to be greater than the theoretical value calculated / Forces of repulsion between the gas particles prevents them from moving closer ✓ (2)

5.6 Lower than ✓ (1)

5.7 Temperature is an indication of the average kinetic energy of the molecules of a gas. If the temperature of a gas decreases, the molecules <u>move slower and closer together</u> ✓up to a point where the gas will start to <u>condense</u> ✓ and not behave like an ideal gas.

OR

The intermolecular forces of attraction become significant then the gas condenses. ✓✓ (2)

5.8 $PV = nRT$ ✓

$(70\ 000)(174 \times 10^{-3})$ ✓$= n(8,31)(293)$ ✓

$n = 5$ moles ✓ (4)

[18]

QUESTION 6

6.1 Temperature ✓

Number of moles of gas ✓ (2)

6.2 Boyle's law ✓ (1)

6.3 Ensure that there is no gas leakage ✓

OR

Wait a minute after changing pressure before you take a reading to ensure that temperature is stabilised ✓ (1)

6.4 Pressure is directly proportional to the inverse of volume ✓✓ (2)

6.5

$m = \frac{p_2 - p_1}{\frac{1}{V_2} - \frac{1}{V_1}}$ ✓

$m = \frac{250000 - 100000}{60000 - 24000}$ ✓

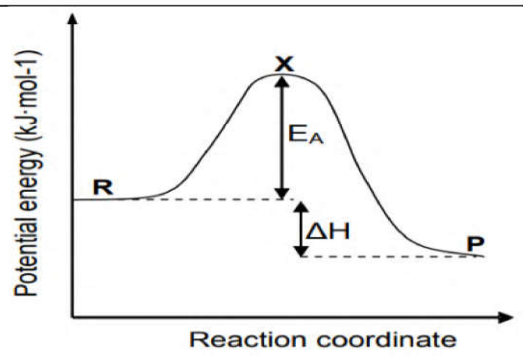
$m = 4.17$ J ✓ (3)

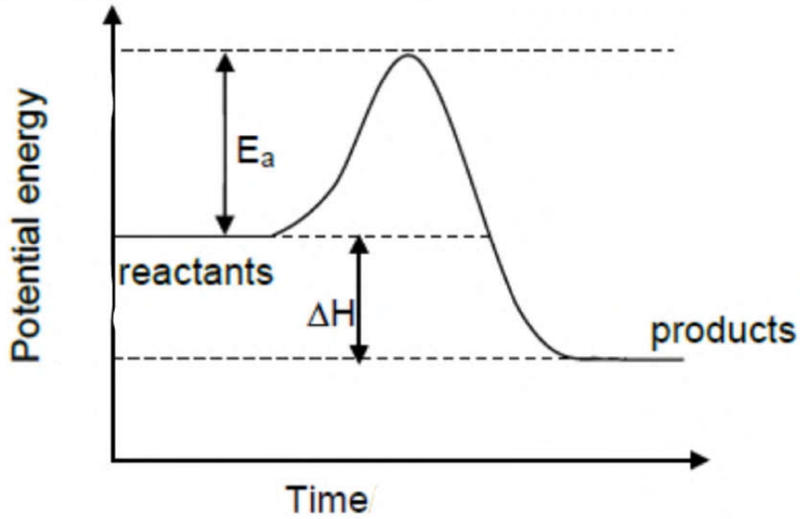
6.6 gradient= nRT ✓ pV = nRT

4.17 □= n(8.31)(298) ✓ 4.17 ✓= n(8.31)(298) ✓

n = 0.00168 mol ✓ n = 0.00168 mol ✓ (4)

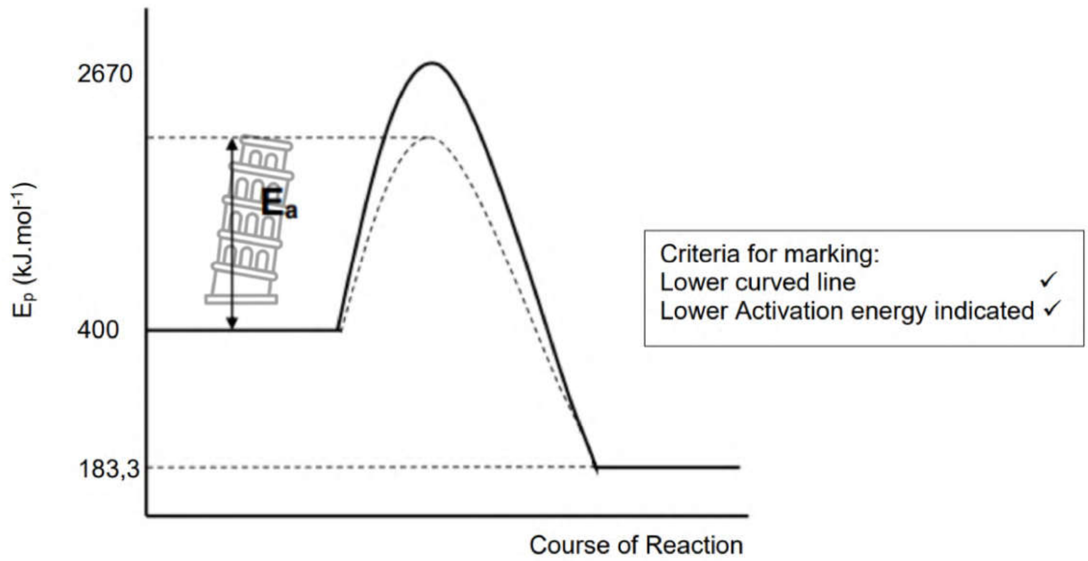
[13]

ENERGY AND CHANGE		
SOLUTIONS		
	QUESTION 1-MULTIPLE CHOICE QUESTIONS MEMO	
1.1	B ✓✓	(2)
1.2	B✓✓	(2)
1.3	C✓✓	(2)
1.4	A✓✓	(2)
1.5	C✓✓	(2)
		[10]
QUESTION 2 MEMO		
2.1	Exothermic ✓ Reactants at higher energy than products / $\Delta H < 0$ ✓	(2)
2.2.1	A✓	(1)
2.2.2	C - B✓	(1)
2.2.3	A-C✓	(1)
2.3	Is a chemical substance used to speed up a chemical reaction. ✓✓	(2)
2.4	It lowers/decreases the activation energy. ✓	(1)
		[8]
QUESTION 3 MEMO		
3.1	The minimum energy needed for a reaction to take place. ✓✓	(2)
3.2	 **Marking guidelines:** Reactants and products correctly labelled ✓ Activated complex ✓ Correct shape as shown ✓ ΔH correctly indicated. ✓ EA correctly indicated. ✓	(5)
3.3.1	- 241,8 $kJ\cdot mol^{-1}$✓	(1)
3.3.2	1 611,8 $kJ\cdot mol^{-1}$ ✓✓	(2)
		[10]
	QUESTION 4 MEMO	
4.1	Exothermic. ✓ Reactants at higher energy than products. /Products at lower energy than reactants. /Energy is released. /$\Delta H < 0$. ✓	(2)
4.2.1	A✓	(1)
4.2.2	A - B✓	(1)
4.2.3	B - C✓	(1)

4.2	1 mol $Ba(OH)_2$ releases: 116 kJ . ✓ 0,18 mol $Ba(OH)_2$ releases: 0,18 x 116✓ = 20,88 KJ✓ (Accept answers in range: 20,3 – 20,88 KJ)	(3)
		[8]
QUESTION 5 MEMO		
5.1	Is the unstable transition state from reactants to products. ✓✓	(2)
5.2	Exothermic reaction. ✓ More energy released than absorbed/ enthalpy change is negative✓	(2)
5.3		(3)

MARKING CRITERIA	
Activation energy E_a correct position and labelled	✓
Heat of reaction H correct position and labelled	✓
Products have lower energy than reactants	✓

		[7]
	QUESTION 6	
6.1	the energy absorbed or released per mole in a chemical reaction. ✓✓	(2)
6.2	More energy is released than absorbed OR energy of products is less than energy of reactants OR $\Delta H < 0$ OR ΔH is negative✓	(1)
6.3	$\Delta H = H_{products} - H_{reactants}$ ✓ $= 183,3 - 400$✓ $= -216,7\ kJ\cdot mol^{-1}$✓	(3)

6.4		(2)
		[8]
QUESTION 7 MEMO		
7.1	Endothermic (reaction) ✓ ΔH is greater than zero/energy is absorbed/ heat is taken in ✓	(2)
7.2	Photosynthesis ✓ • During endothermic reactions, more energy is absorbed than released. ✓ • The graph shows that the energy of the products is more than that of the reactants which indicates that more energy was absorbed than released. ✓	(3)
7.3	A – EA/activation energy ✓ B – Δ /heat of reaction/enthalpy change ✓	(2)
7.4	Enzymes increase the reaction rate ✓by lowering the activation energy. ✓	(2)
		[9]

ACIDS AND BASES			
SOLUTIONS			
QUESTION1: MULTIPLE CHOICES			
1.1	B	✓✓	(2)
1.2	A	✓✓	(2)
1.3	C	✓✓	(2)
1.4	C	✓✓	(2)
			[14]
QUESTION 2			
2.1	$NH_4^+ + HCO_3^-$ ✓ $\rightarrow H_2CO_3 + NH_3$ ✓✓		(3)
2.2	A pair of compounds or ions that differ by the presence of one H^+ ion. ✓✓		(2)
2.3	HCO_3^- ✓ and NH_3 ✓		(2)
2.4			
	2.4.1	Ampholyte ✓	(1)
	2.4.2	$HSO_4^- + H_2O$ ✓ $\rightleftharpoons SO^{2-}_4 + H_3O^+$ ✓ $HSO_4^- + H_2O$ ✓ $\rightleftharpoons H_2SO_4 + OH^-$ ✓	(4)
			[12]
QUESTION 3			
3.1			
	3.1.1	A base is proton acceptor✓✓	(2)
	3.1.2	$H_2SO_4(aq) + 2NaOH(aq)$ ✓ $\rightarrow Na_2SO_4(aq) + 2H_2O(\ell)$ ✓✓	(3)
	3.1.3	Sodium sulphate✓✓	(2)
	3.1.4	HSO_4^- ✓✓	(2)
	3.1.5	HSO_4^- and H_2SO_4 ✓✓ H_2O and H_3O^+ ✓✓	(4)
3.2			
	3.2.1	**OPTION 1** $c = \frac{m}{MV}$ ✓ $= \frac{6 ✓}{(40)(0.5) ✓} = 0.3\ mol.dm^{-3}$ ✓ **OPTION 2** $n = \frac{m}{M} = \frac{6}{40}$ ✓ $= 0.15\ mol$ $c = \frac{n}{v}$ ✓ $= \frac{0.15}{0.5}$ ✓ $= 0.3\ mol.dm^{-3}$	(4)
	3.2.2	$n(NaOH) = \frac{m}{M} = \frac{6}{40}$ ✓ $= 0.15\ mol$ $n(NaOH):n(NH4Cl)$ 1 : 1 ✓ $n(NaOH) = n(NH4Cl) = 0.15\ mol$ $n = \frac{m}{M}$ $0.15 = \frac{m}{53,5}$ ✓ $\therefore m(NH4CL) = 80.25g$ $\%purity = \frac{mass\ pure}{mass\ impure} X100 = \frac{8.025}{10} X100 = 80.25\%$ ✓	

		percentage impurities in the NH4Cℓ $= 100 - ✓80.25 = 19{,}75\%$✓	(6)
			[23]
QUESTION 4			
4.1			
	4.1.1	A✓	(1)
	4.1.2	B✓	(1)
	4.1.3	C✓	(1)
4.2			
	4.2.1	$HC\ell(g) + H_2O(\ell)$ ✓→ $H_3O^+(aq) + C\ell^-(aq)$ ✓✓	(3)
4.3		$c = \frac{m}{MV}$✓ $\quad 0.12$✓ $= \frac{m}{(138)(0.2)✓} = 3.312g$✓	(4)
4.4			
	4.4.1	Organic dye with a specific colour in acid and base✓	(1)
	4.4.2	$n(CH_3COOH) = C.V$✓ $= (0.12)(0.0251) = 0.003012mol$ $n(CH_3COOH): n(K_2CO_3)$ 2 : 1✓ $n(K_2CO_3) = 0.001506\,mol$ $c = \frac{n}{v} \therefore 0.12 = \frac{0.001506}{V}$✓ $\quad V(K_2CO_3) = 0.01255dm^3$✓	(4)
4.5			
	4.5.1	$2HC\ell(aq) + Mg(s) \rightarrow MgC\ell_2(aq) + H_2(g)$	(4)
	4.5.2	$MgO + H_2O \rightarrow Mg^{2+} + OH^-$	(2)
4.6			
	4.6.1	Acid – sulphuric acid Base – sodium hydroxide	(2)
	4.6.2	$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell)$	(3)
			[26]

REDOX REACTIONS			
SOLUTIONS			
QUESTION 1			
1.1	A✓✓		
1.2	C✓✓		
1.3	D✓✓		
1.4	B✓✓		
1.5	C✓✓		
			[10]
QUESTION 2			
2.1	Oxidation is the increase in oxidation numbers ✓✓		(2)
	2.2.1	$Cu(s)$✓✓	(2)
	2.2.2	Silver ion ✓✓	(2)
	2.2.3	$Cu \rightarrow Cu^{2+} + 2e^-$	(2)
	2.2.4	$Cu \rightarrow Cu^{2+} + 2e^-$ ✓ $Ag^+ + e^- \rightarrow Ag$ ✓ $Cu + 2Ag^+$✓ $\rightarrow Cu^{2+} + 2Ag$✓ balancing	(4)
2.3	Cu + 2AgNO3 → Cu(NO3)2 + 2Ag +1 0 Ag+ oxidation number changes from +1 to 0, gaining electrons, reduction. ✓✓		(2)
			[14]
QUESTION 3			
3.1	Reduction is a decrease in oxidation number ✓✓		(2)
3.2	Mn is +7 / Mn^{7+} ✓		(1)
3.3	H_2S / S^{2-} ✓		(1)
3.4	The oxidation number of S increases ✓ from -2 to 0 ✓		(2)
3.5	MnO_4^- / Mn^{+7} ✓		(1)
3.6	$H_2S(g) \rightarrow S + 2H^+ + 2e^-$ ✓✓		(2)

3.7	$H_2S \rightarrow S + 2H^+ + 2e^-$ $MnO_4^- + 8H^+ + 5e^- \rightarrow 2Mn^{2+} + 4H_2O$ ✓ $2MnO_4^- + 5H_2S + 6H^+ \rightarrow 2Mn^{2+} + 5S + 8H_2O$ ✓ balancing ✓equation	(3)
		[12]
QUESTION 4		
4.1	Cr^{6+} (+6) ✓✓	(2)
4.2	Gain of electrons ✓	(1)
4.3	Fe^{2+}, ✓ the oxidation number increases from +2 to +3 ✓	(2)
4.4	$Cr^{6+}/Cr_2O_7^{2-}$ ✓✓	(2)
4.5	$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	(1)
4.6	$6Fe^{2+} \rightarrow 6Fe^{3+} + 6e^-$ ✓ $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2$ $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$✓✓	(3)
		[13]
QUESTION 5		
5.1	A reaction in which electrons are transferred. ✓✓	(2)
	5.2.1 +7✓	(1)
	5.2.2 +2✓	(1)
5.3	Reduction✓ The oxidation number decreased. ✓ OR Electrons are gained.	(2)
5.4	(Reaction) 1 ✓ Oxidation number (of S) decreases ✓ from +4 (in SO_2) to 0 (in S)	(2)
5.5	$H_2S \rightarrow S + 2H^+ + 2e^-$ ✓✓	(2)
5.6	$H_2S \rightarrow S + 2H^+ + 2e^-$ (x2) $SO_2 + 4H^+ + 4e^- \rightarrow S + 2H_2O$ ✓	(4)

	$2H_2S + SO_2 \rightarrow$ ✓ $3S + 2H_2O$ ✓ Bal. ✓	
		[14]