education

Department:
Education
PROVINCE OF KWAZULU-NATAL

CURRICULUM GRADE 10 -12 DIRECTORATE

NCS (CAPS)

LEARNER ACTIVITY DOCUMENT

GRADE 12

PHYSICAL SCIENCES

STEP AHEAD PROGRAMME

SOLUTIONS 2021

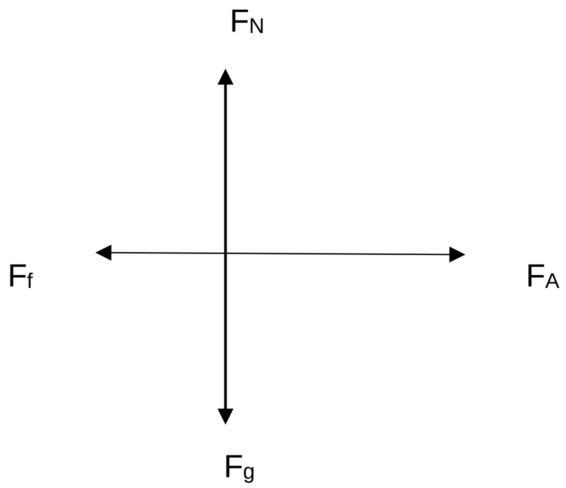
PREFACE

This support document serves to assist Physical Sciences learners on how to deal with curriculum gaps and learning losses as a result of the impact of COVID-19 in 2020. It also captures the challenging topics in the Grade 10 -12 work. Activities should serve as a guide on how various topics are assessed at different cognitive levels and also preparing learners for informal and formal tasks in Physical Sciences. It will cover the following topics:

SOLUTIONS

Question 1

1.1



1.2 Force and displacement

1.3.1 $W_A = F_A\ \Delta x \cos\theta$

$= 50N \times 10m \times \cos 0°$

$= 500J$

1.3.2 $W_f = F_f\ \Delta x \cos\theta$

$= 5N \times 10m \times \cos 180°$

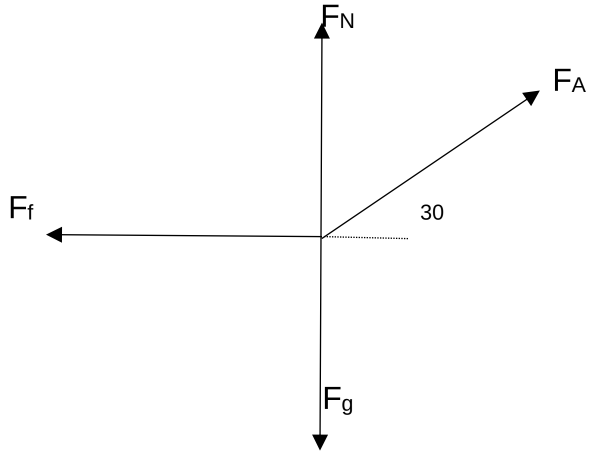
$= -50J$

1.3.3 $W_{net} = W_A + W_f + F_N + W_{Fg}$

$= 500J + (-50J) + 0J + 0J$

$= 450J$

QUESTION 2



$W = F\Delta x\cos\theta$

2.1.1 $W_A = F_{net}\Delta x \cos 0°$

$= 15\cos 30°.\ 8m.\ \cos 0°$

$= 106.92J$

$W_f = F_f \Delta x \cos\theta$

$mg = N + F_v$

$F_N = mg - F\sin\theta$

$= 3 \times 9.8 - 15\sin 30°$

$= 21.9N$

$F_N = \mu k\ N$

$= 0.2 \times 21.9N$

$= 4.38N$

$W_f = F_f\ \Delta x\cos\theta$

$= 4.38N \times 8m\ \cos 180°$

$= -35.04J$

$W_{net} = W_A + W_f$

$= 106.92J + (-35.04J)$

$= 71.88J$

ACTIVITY 1

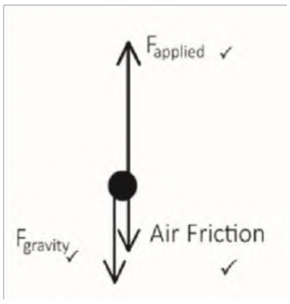
1. The net/total work done on an object is equal to the change in the object's kinetic energy. OR The work done on an object by a net force is equal to the change in the object's kinetic energy.

2. 

3. $W_g = F_g\ \Delta x\cos\theta$
 $= mg\Delta x\cos\theta°$
 $= (6)(9,8)(1,6)\cos 0^o$
 $= 94,08\ J$
4. $W_{net} = \Delta E_K$

$W_f + W_g + W_N = ½m(v_f^{\,2} – v_i^{\,2})$
$(0,4)(4)(9,8)(1,6)\cos180^o + 94,08 + 0 = ½(4)(v_f^{\,2} – 0) + ½(6)(v_f^2 – 0)$
$v_f = 3,71\ m·s^{-1}$

ACTIVITY 2

1. The net/total work done on an object is equal to the change in the object's kinetic energy. OR The work done on an object by a net force is equal to the change in the object's kinetic energy.
2. 

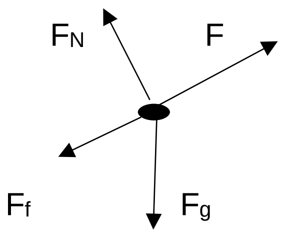
3. Gravitational force or weight of the soldier.
4. $W_{net} = \Delta E_k$
$W_{Fg} + W_T + W_f = \Delta E_k$
$F_g\Delta y\cos\theta + F_T\Delta y\cos\theta + F_f\Delta y\cos\theta = \Delta E_k$
$(960)(20)\cos0^\circ + (80)(9,8)\cos 180^\circ + W_f = 0$
$19200 – 15680 + W_f = 0$
$W_f = 3520\ J$
5. 6. Air friction and Force of gravity

ACTIVITY 3

1.

The net (total) work done on an object is equal to the change in kinetic energy of the object. OR The work done on an object by a net (resultant) force is equal to the change in kinetic energy of the object.

2.

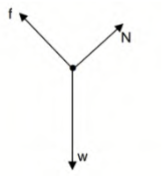


3. $W_{net} = \Delta E_k$
$W_w + W_f + W_F = ½\ mv_f^2 - ½\ mv_i^2$

$mg\Delta x\cos\theta + W_f + W_F = ½ mv_f^2 - ½ mv_i^2$
$(1500)(9,8)200\cos180^o + W_f + 4,8 \times 10^6 = ½ (1\,500)(25^2 – 0)$
$-2\,940\,000 + W_f + 4,8 \times 10^6 = 468\,750$
$W_f = -1,39 \times 10^6$ J

ACTIVITY 4

1.



2. The net/total work done on an object is equal to the change in the object's kinetic energy. OR The work done on an object by a net force is equal to the change in the object's kinetic energy.
3. $W_{net} = \Delta E_k$
$W_{g//} + W_f = ½ mv_f^2 - ½ mv_i^2$
$mg\sin\theta\Delta x\cos\theta + F_f\Delta x\cos\theta = ½ mv_f^2 - ½ mv_i^2$
$(60)(9,8)\sin20^o(25) \cos0^\circ + (50)(25) \cos180^o = ½ (60)(15)^2 - ½ (60)v_i^2$
$-1250+5027,696 = 6750- 30v_i^2$
$V_i = 9.95$ m·s^{-1}

SOLUTIONS:

ACTIVITY 1

1.1
$E_p = mgh.$
$E_p = (100)(9.8)(5).$
$E_p = 4900J.$

1.2
$E_{mech(top)} = E_{mech(bottom)}.$
$E_k + E_p = E_k + E_p.$
$0 + 4900 = E_k + 0.$
$E_k = 4900J.$

1.3
$E_k = \frac{1}{2}mv^2.$
$4900 = \frac{1}{2}(100)v^2.$
$v = 9.9m \cdot s^{-1}.$

Question 2:
1.

$E_{mech(top)} = E_{mech(bottom)}$.
$E_{k(top)} + E_{p(top)} = E_{k(bottom)} + E_{p(bottom)}$.
$0 + 0.5(9.8)(10) = \frac{1}{2}(0.5)v^2 + 0$.
$v = 14m/s$.

2.
$E_{p(top)} = mgh$.
$E_{p(top)} = 60(9.8)(10)$.
$E_p = 5800J$.

$E_{p(bottom)} = mgh$.
$E_{p(bottom)} = 60(9.8)(0)$.
$E_{p(bottom)} = 0J$.
$\therefore$ difference in $E_p = E_{p(top)} - E_{p(bottom)}$.
difference in $E_p = 5800 - 0$.
$\Delta E_p = 5800J$.

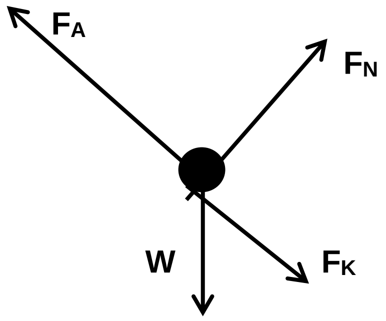
ACTIVITY 2
1. Energy is neither created nor destroyed; it can ONLY be converted from one form to another.
2. The total mechanical energy of an isolated system remains constant
3. Is a force whose work done in moving an object between two points does not depend on the path taken. For example, gravitational force.
4.
   a) No, when frictional force acts on the child, some of the mechanical energy of the child is dissipated to the surroundings.
   b) $W = F \cdot \Delta x Cos\theta$.

   $W_g = mg \cdot hCos\theta$.

   $W_g = 38(9.8)(2)Cos0$.

   $W_g = 744.8J$.

ACTIVITY 3
Question 1.
a).



b).

Conservative Force

- W.Non-conservative force.
- F_K.
- F_A.

Question 2

2.1. E_{mech} is not conserved.

The system is not isolate/there is frictional force.

2.2.1. A force for which the work done in moving an object between two points does not depend on the path taken.

2.2.2. Gravitational force.

2.3.1.

$E_k = \frac{1}{2}mv^2.$

$E_k = \frac{1}{2}(55)(10)^2.$

$E_k = 2750J.$

2.3.2.

$W_{nc} = \Delta E_k + \Delta E_p.$

$W_f = \Delta E_k + \Delta E_p.$

$f_k\Delta x \cdot Cos\theta = E_{k(B)} - E_{k(A)} + E_{p(B)} - E_{p(A)}.$

$8(8)Cos180 = E_{k(B)} - 2750 + (55)(9.8)(1.2) - 0.$

$E_{k(B)} = 1959.2J.$

2.3.3.

$W_{net} = \Delta E_k.$

$W_N + W_f + W_g = E_{k(B)} - E_{k(A)}.$

$0 + 8(8)Cos180 + 55(9.8)(1.2)Cos180 = E_{k(B)} - 2750.$

$E_{k(B)} = 1959.2J.$

1. Power is the rate at which work is done.

2
- W.
- $J \cdot s^{-1}.$

3.1 $W = F\Delta xCos\theta.$

$W = (120)(3)Cos0.$

$W = 360J.$

$P = \frac{W}{\Delta t}.$

$P = \frac{360}{5}.$

$P = 72W.$

3.2 $W = F\Delta xCos\theta.$

$W = (20)(3)Cos180.$

$W = -60J.$

$P = \frac{W}{\Delta t}.$

$P = \frac{60}{5}.$

$P = 12W.$

4.1 $W = F\Delta x Cos\theta.$

$W = (750)(10\,000)Cos180.$

$W = -7\,500\,000J.$

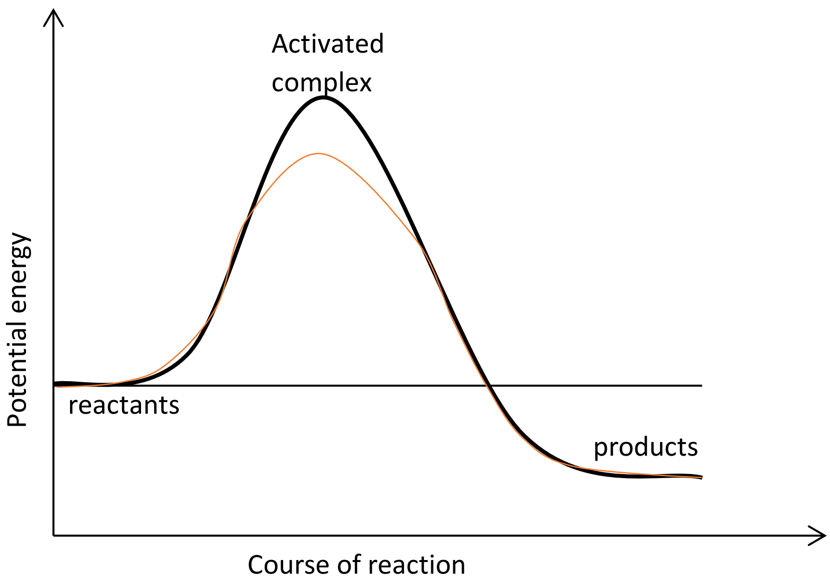
4.2 $110Km \cdot h^{-1} = 30.56m \cdot s^{-1}.$

$P_{av} = F \cdot v_{av}.$

$P_{av} = 750(30.56).$

$P_{av} = 22\,920W.$

Worksheet: Reaction rate solutions

<table>
<tr><td colspan="3">QUESTION 1</td><td></td></tr>
<tr><td>1.1</td><td></td><td></td><td></td></tr>
<tr><td></td><td>1.1.1</td><td>Minimum energy needed for the chemical reaction to start</td><td>(2)</td></tr>
<tr><td></td><td>1.1.2</td><td>Reaction that releases energy during chemical reaction</td><td>(2)</td></tr>
<tr><td></td><td>1.1.3</td><td>Reaction that absorbs energy during the chemical reaction</td><td>(2)</td></tr>
<tr><td></td><td>1.1.4</td><td>Unstable transition state from reactants to products</td><td>(2)</td></tr>
<tr><td>1.2</td><td></td><td></td><td></td></tr>
<tr><td></td><td>1.2.1</td><td>Exothermic reaction, ΔH < 0 or energy of products is less tan energy or reactants</td><td>(3)</td></tr>
<tr><td></td><td>1.2.2</td><td>Heterogeneous</td><td>(1)</td></tr>
<tr><td></td><td>1.2.3</td><td>


</td><td>(2)</td></tr>
<tr><td colspan="3">QUESTION 2</td><td></td></tr>
<tr><td>2.1</td><td></td><td>Sufficient kinetic energy of particles
Correct orientation of particles</td><td>(2)</td></tr>
</table>

QUESTION 3			
3.			
	3.1	Change in concentration of reactants or products	(2)
	3.2	HCl has a higher concentration Reaction mixture is heated thus temperature is higher Zinc powder has been used resulting to a larger surface area	(6)
	3.3	Addition of positive catalyst Nature of a reactant	(2)
4.		Average rate = $\frac{\Delta c}{\Delta t}$ $= \frac{1,45 - 1,90}{15 - 0}$ $= -0,03\ mol \cdot dm^{-3}$ $= 0,03\ mol \cdot dm^{-3}$	
5.		The more water gets hotter the higher the temperature, according to collision theory, • The speeds of the particles increase • The average kinetic energy of the particles increases • More particles have sufficient kinetic energy • Which increases the number of effective collisions taking place per unit time • Thus, rate of reaction increases	
6.			
	6.1	The higher the amount of the metal, the higher the volume of the hydrogen gas produced	(2)
	6.2	Concentration of HCl Volume of HCl Temperature	(2)
	6.3	The reaction has reached completion/ reaction has stopped/ reactants has been used up	(2)
	6.4	125 cm^3	(2)

CLASS ACTIVITY SOLUTIONS

1) Consider the following reaction that has reached equilibrium at 200 °C.

$N_2(g) + 2CO_2(g) \rightleftharpoons 2NO(g) + 2CO(g)$

After equilibrium was reached, certain changes were made to the conditions affecting the system. State in each case how the amount of NO(g) will be affected if:
(Write down only INCREASES, DECREASES or STAYS THE SAME.)

a) A suitable catalyst is added
Remain the same
b) Some of the carbon monoxide (CO) is removed
increases

2) The following reversible reaction reaches equilibrium at 500 K

$2A_2X(g) + BA_2(g) \rightleftharpoons 3A_2(g) + BX_2(s)$

For each of the following questions choose what will happen to the amount of $BA_2(g)$ and write down one of the following answers: INCREASE, DECREASE, NO CHANGE.
More $A_2X(g)$ is added?
increase, overall reaction rate increases, forward reaction is favoured, amount of reactants decrease, amount of products increases

b) $BX_2(s)$ is removed
no change, solids have no effect on the equilibrium

SUGGESTED SOLUTIONS TO EXTRA QUESTIONS

1. B
2. C
3. B
4. C
5. A
6. D
7. A
8. D
9. D
10. B

CHEMICAL EQUILIBRIUM LESSON 3_SOLUTIONS

QUESTION 1

1.1

1.1.1

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

Ratio	**1**	**1**	**2**
***n*Initial (mol)**	**1**	**1**	**0**
***n*Change (mol)**	(-1a) **-0.4**✓	(-1a) **-0.4**	(+2a) ✓ **+0.8**
***n*Equilibrium (mol)**	**0.6**	**0.6**	**0.8**✓
Volume (dm^3)	**1**	**1**	**1**
[equilibrium] mol/dm^3	**0.6**	**0.6**	**0.8**✓

Correct Table format✓

(5)

1.1.2 Homogenous, system contains gases only✓ (one phase) (2)

1.1.3 Increase in temperature✓ (2)
Increase in pressure ✓
Add a catalyst✓
Increase concentration of reactants ✓ (any TWO)

1.2 A✓✓ (2)

[11]

QUESTION 2

2.1

2.1.1 22.4 dm^3 ✓ (1)

2.1.2 . $n(SO_3)\,at\ equilibrium = {}^{V}/_{V_m} = {}^{0.22}/_{22.4} = 9,82\ x\ 10^{-3} mol$ (6)

Table ✓

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Ratio	**2**	**1**	**2**
***n*Initial (mol)**	**4**	**3**	**0**
***n*Change (mol)**	(-2y) **-0.00982**	(-y) **-0.00491**	(+2y) ✓ **0.00982**
***n*Equilibrium (mol)**	**3,99**	**2,995**✓	**0.00982**✓
Volume (dm^3)	**4**	**4**	**4**
[equilibrium] mol/dm^3	**0.998**	**0,749**	**0.00246**✓

2.1.3 DECREASE✓ (1)

[08]

QUESTION 3

3.1

3.1.1 B✓✓ (2)

	3.1.2	Dynamic equilibrium/ chemical equilibrium ✓	(1)
3.2			
	3.2.1	Reversible reaction✓	(1)
	3.2.2	Endothermic✓, ΔH > 0 meaning energy is absorbed✓	(2)
	3.2.3	$n = {}^{m}/_{M} = {}^{168}/_{28}$ = 6 mol (CO) at equilibrium	(6)

$CO_2(g) + C(s) \rightleftharpoons 2CO(g)$

Ratio	**1**	**1**	**2**
***n*Initial (mol)**	**X**		**0**
***n*Change (mol)**	**(-1a) -3**	**(-1a) -3✓**	**(+2a) +6✓**
***n*Equilibrium (mol)**	**x-3✓**		**6✓**
Volume (dm^3)	**2**		**2**
[equilibrium] mol/dm^3	$\frac{x-3}{2}$		**3✓**

[12]

Question 1

1.1

1.1.1 (5)

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

Ratio	**1**	**1**	**2**
***n*Initial (mol)**	**1**	**1**	**0**
***n*Change (mol)**	**(-1a) -0.4**	**(-1a) -0.4**	**(+2a) +0.8**
***n*Equilibrium (mol)**	**0.6**	**0.6**	**0.8**
Volume (dm^3)	**1**	**1**	**1**
[equilibrium] mol/dm^3	**0.6**	**0.6**	**0.8**

1.1.2 **Homogenous, system contains gases only (one phase)** (2)

1.1.3 **Increase in temperature**
Increase in pressure
Add a catalyst
Increase concentration of reactants (2)

1.2 **A** (2)

[11]

QUESTION 2

2.1

2.1.1 **22.4 dm^3** (1)

2.1.2 . $n(SO_3\ )at\ equilibrium = {}^{V}/_{V_m} = {}^{0.22}/_{22.4} = 9{,}82\ x\ 10^{-3} mol$ (6)

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Ratio	**2**	**1**	**2**
***n*Initial (mol)**	**4**	**3**	**0**
***n*Change (mol)**	(-2y) **0.00982**	(-y) **0.0 04 91**	(+2y) **0.009 82**
***n*Equilibrium (mol)**	**3,99**	**2,99 5**	**0.009 82**
Volume (dm^3)	**4**	**4**	**4**
[equilibrium] mol/dm^3	**0.998**	**0,74 9**	**0.002 46**

2.1.3 **DECREASE** (1)

			[08]
QUESTION 3			
3.1			
	3.1.1	**B**	(2)
	3.1.2	**Dynamic equilibrium/ chemical equilibrium**	(1)
3.2			
	3.2.1	**Reversible reaction**	(1)
	3.2.2	**Endorthemic, ΔH > 0 meaning energy is absorbed**	(2)
	3.2.3	$n = {}^{m}/_{M} = {}^{168}/_{28}$ = 6 mol (CO) at equilibrium	(6)
			[12]

$CO_2(g) + C(s) \rightleftharpoons 2CO(g)$

Ratio	**1**	**1**	**2**
***n*Initial (mol)**	**X**		**0**
***n*Change (mol)**	**(-1a) -3**	**(-1a) -3**	**(+2a) +6**
***n*Equilibrium (mol)**	**x-3**		**6**
Volume (dm^3)	**2**		**2**
[equilibrium] mol/dm^3	$\frac{x-3}{2}$		**3**

QUESTION 1

1.1 D ✓✓ (2)

1.2

1.2.1 (6)

$$PCl_5 (g) \rightleftharpoons PCl_3 (g) + Cl_2 (g)$$

Ratio	1	1	1
*n*Initial (mol)	0.375	0	0
nChange (mol)	(-1x) -0.125	(-1x) -0.125	(+1x)✓ 0.125
nEquilibrium (mol)	0.25	0.125✓	0.125
Volume (dm^3)	1	1	1
[equilibrium] mol/dm^3	0.250	0.125	0.125✓

$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]}$ ✓

$= \frac{(0,125)(0,125)}{(0,25)}$ ✓

$= 6,25 \times 10^{-2}$ ✓

1.2.2 At equilibrium the concentration of products is lower than the concentration of reactants✓✓ (2)

[10]

QUESTION 2

2.1

2.1.1 A state when the rate of the forward reaction is equal to the rate of the reverse reaction. ✓✓ (2)

2.1.2 $n = {}^{m}/_{M} = {}^{1.12}/_{28}$ = 0.04 mol (CO) at equilibrium (8)

Let ***n***Initial =y

$$COBr_2(g) \rightleftharpoons CO(g) + Br_2(g)$$

Ratio	1	1	1
*n*Initial (mol)	y	0	0
nChange (mol)	(-1x) -0.04	(+1x) +0.04	(+1x)✓ +0.04

nEquilibrium (mol)	y-0.04✓	0.04	0.04✓
Volume (dm^3)	2	2	2
[equilibrium] mol/dm^3	$\frac{y-0.04}{2}$	0.02	0.02✓

$Kc = \frac{[Br_2][CO]}{[COBr_2]}$✓

✓ $0.19 = \frac{0.02 \times 0.02}{[COBr_2]}$✓

$= 0.00211 mol/dm^3$✓

	2.1.3	$\frac{y-0.04}{2} = 0.00211$✓ $y = 0.044$✓ $\%decomposed = \frac{0.04}{0.044}$✓$\times 100$ $= 90.91\%$✓	(4)
	2.1.4	Kc< 0,19✓✓	(2)
	2.1.5	NO CHANGE✓	(1)
			[15]
QUESTION 3			
3.1			
	3.1.1	increase✓	(1)
	3.1.2	decrease✓	(1)
3.2			

	3.2.1	**nInitial O_2(g)** $= {}^{m}/_{M} = {}^{x}/_{32} = 0.031x$	(8)

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Ratio	2	1	2
*n*Initial (mol)	4	0.031x✓	0
*n*Change (mol)	(-2y) -3	(-y) -1.5	(+2y)✓ +3
*n*Equilibrium (mol)	1	0.031x-1.5✓	3
Volume (dm^3)	2	2	2
[equilibrium] mol/dm^3	0.5	$\frac{0.031x - 1.}{2}$	1.5✓

$Kc = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$✓

4.5✓$= \frac{(1.5)^2}{0.5^2} \times \frac{0.031x-1.5}{2}$✓

$x = 176.00\ g$✓

	3.2.2	$\frac{1}{4.5} = 0.222$✓	(1)
			[11]
4.1		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. ✓✓	
4.2		Endothermic ✓ Decrease in temperature favours the exothermic reaction✓. The reverse reaction is favoured./OR Number of moles/amount/concentration of N_2O_4 gas increases. OR Number of moles/amount of NO_2 decreases. ✓	(3)
4.3		.	
	4.3.1	Increases✓	(1)
	4.3.2	Remains the same✓	(1)
	4.3.3	Increases✓	(1)

4.4		***n*Equilibrium N_2O_4(g)= 80% of x= 0.8x✓**	(8)

$N_2O_4(g) \rightleftharpoons 2\ NO_2(g)$)

Ratio	1	2
*n*Initial (mol)	x	0
*n*Change (mol)	(-y) -0.2x✓	(+2y) ✓ +0.4x
*n*Equilibrium (mol)	0.8x✓	0.4x
Volume (dm^3)	2	2
[equilibrium] mol/dm^3	0.4x	0.2x✓

$Kc = \frac{[NO_2]^2}{[N_2O_4]}$✓

0.16✓$= \frac{(0.2x)^2}{0.4x}$✓

$x = 1.60\ mol$✓

[16]

CHEMICAL EQUILIBRIUM

GRAPHS

SOLUTIONS

MCQ

1.1.1 A
1.1.2 C
1.1.3 C
1.1.4 A

QUESTION TWO (ONE WORD ANSWERS)

2.1 catalyst

2.2 temperature

2.3 chemical equilibrium

2.4 reversible

2.5 Kc

3.

3.1.1 The concentration of nitrogen √ was increased √ / or more nitrogen was added√√

3.1.2 The pressure √ was increased √.

3.1.3 The temperature √ was increased√

3.2 t_1 √ and t_2 √

EX 4

4.1 The stage in a chemical reaction in which the rate of the forward reaction is equal to the rate of the reverse reaction . √√

4.2.1 Higher than. √

4.2.2 Equal to. √

4.3.1 NO_2 is added. √

4.3.2 The pressure was increased. √

4.4 Increases √

An increase in temperature favours the endothermic reaction. √
The forward reaction is endothermic. √

EX 5.

5.1 The reaction reached equilibrium √

5.2 Concentration of H_2 was increased, or Some H_2 was added at t_1. ✓ The concentration of HI then increased/more HI was formed✓ while some H_2 and I_2 were used up ✓until equilibrium was re-established at t_2. ✓

EX 6

6.1 The reaction is at equilibrium.√

6.2 The concentration of NH_3 was increased or more NH_3 was added.√

6.3 According to Le Chatelier's Principle the reverse reaction will favoured. √
The concentrations of of N_2 and H_2 increases √ and concentrations of NH_3 decreases√.

EX 7

7.1 A reaction is reversible when products can be converted back to reactants. √

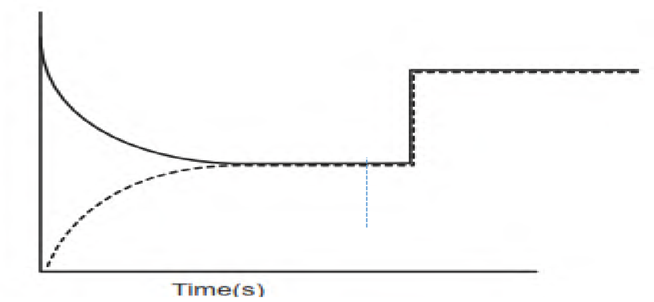
7.2 No change.√

7.3.1 Temperature decreases √

7.3.2 Decrease in temperature decreases the rate of both forward and reverse reactions. √
Decrease in temperature favours the exothermic reaction. √
The reverse (exothermic) reaction is faster or reverse reaction is favoured.
Or the forward (endothermic) reaction will be slower. √

EX 8

8.1 When the rate of forward reaction is equal to reverse reaction.√√



Page 2

EX 9

9.1 Amount/number of moles/volume of (gas) reactants equals amount/number of moles/volume of (gas) products. ✓

OR A change in pressure will change the concentration of the reactants and products equally.
9.2 (Chemical/dynamic) equilibrium.✓ **OR** The rate of the forward reaction equals the rate of the reverse reaction.
9.3 Addition of a catalyst ✓
Increase in pressure ✓
9.4.1

Endothermic ✓

- The rate of the forward reaction decreases more./The rate of the reverse reaction decreases less. ✓
- A decrease in temperature favours the exothermic reaction. ✓

9.4.2 Decreases
9.5 Reactants/H_2/I_2 removed ✓

POSSIBLE ANSWERS-LESSON 1

CW ACTIVITY

1.Complete the following table of salts formed during acid-base reactions

1.

Acid/Base	**HCl**	**HNO_3**	**H_2SO_4**
KOH	**KCl**	**KNO_3**	**K_2SO_4**
NaOH	NaCl	$NaNO_3$	Na_2SO_4
Na_2O	NaCl	$NaNO_3$	Na_2SO_4
MgO	$MgCl_2$	$Mg(NO_3)_2$	$MgSO_4$
$NaHCO_3$	NaCl	$NaNO_3$	Na_2SO_4
$CaCO_3$	$CaCl_2$	$Ca(NO_3)_2$	$CaSO_4$

2. NAME THE FOLLOWING ACIDS, BASES OR IONS

2.1 NaOH sodium hydroxide
2.2 CH_3COOH ethanoic acid
2.3 $(COOH)_2$ oxalic acid
2.4 $Ca(OH)_2$ calcium hydroxide
2.5 HNO_3 nitric acid
2.6 H_2SO_4 sulphuric acid
2.7 $NaHCO_3$ sodium hydrogen carbonate

2.8 H_3O^+ hydronium / oxonium ion
2.9 HSO_4^- hydrogen sulphate ion
2.10 CO_3^{2-} carbonate ion
2.11 NH_4^+ ammonium ion
2.12 HCO_3^- hydrogen carbonate ion
2.13 NH_3 ammonia

3. CHEMICAL FORMULAE:

$n = \frac{V}{V_m}$ $n = \frac{m}{M}$ $c = \frac{n}{V}$ $c = \frac{m}{MV}$

3.1 Calculate the concentration of a 0,2 mol solution of Na_2CO_3 with a volume of 150 cm^3. (3)

Solution

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

$c = \frac{0,2}{0,15}$

= 1,33 $mol.dm^{-3}$

3.2 Calculate the number of mol of NaOH in 250 cm^3 solution of concentration of 0,25 $moldm^{-3}$ (3)

Solution

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

$0,25 = \frac{n}{0,25}$

n= 0,0625 mol

3.3 Calculate the mass of NaCl needed to prepare a solution of concentration 0,2 $moldm^{-3}$ in a 150 ml flask. (3)

Solution

$c = \frac{m}{MV}$

$0,2 = \frac{m}{58,5\ X\ 0,15}$

m= 1,76 g

3.4 Calculate the concentration of H^+ ions in 0,25 $moldm^{-3}$ H_2SO_4. (3)

Solution

1 H_2SO_4 : $2H^+$

1 : 2

$[H^+] = 2 [H_2SO_4]$

$= 0,25 \times 2$

$= 0,50$ mol.dm^{-3}

3.5 210 g of impure sodium hydrogen carbonate reacts with excess hydrochloric acid to form 44,8 dm^3 of carbon dioxide gas at STP .The balanced equation for this reaction is given below.

$$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$$

Calculate the % purity of sodium hydrogen carbonate in this mass. (5)

Solution

1 $NaHCO_3$ = 1 CO_2

$n_{NaHCO_3} = n_{CO_2}$

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

$n = \frac{44,8}{22,4}$

$= 2$ mol

$n_{NaHCO_3} =$

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

$2 = \frac{m}{84}$

m = 168g

The mass of pure $NaHCO_3$ = 168 g

% purity = $\frac{168}{210} \times 100$

= 80 %

3.6 Consider the following balanced chemical reaction between calcium carbonate and nitic acid.

$CaCO_3 + 2 HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$

Calculate the mass of $CaCO_3$ needed to completely react with 30 cm^3 solution of nitric acid of concentration 0,0125 moldm^{-3}. (5)

Solution

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

$0,0125 = \frac{n}{0,03}$

n= 0,000375 mol

n (HNO_3) : n ($CaCO_3$)

2 : 1

n ($CaCO_3$) = 0,000375 ÷ 2

= 0,0001875 mol

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

m

HOMEWORK POSSIBLE ANSWERS

1. *Solution*

$n\ (NaCl) = \frac{m}{M}$

$n = \frac{14,625}{58,5}$

n= 0,25 mol

Ratio Na_2CO_3 : NaCl

1 : 2

$n(Na_2CO_3)$ = 0,125 mol

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

$0,125 = \frac{m}{106}$

m= 13,25g

$\%purity = \frac{mass\ of\ pure\ substance}{Mass\ of\ impure\ substance} x100$

$\%purity = \frac{13,25}{20} x\ 100$

2.
   - 2.1 An acid that ionises completely in water to produce a high concentration of hydronium ions
   - 2.2 It can donate two protons/Hydrogen ions per molecule

3
   - 3.1 Ampholyte
   - 3.2 H_2CO_3

4.
   - 4.1 It is a proton acceptor
   - 4.2 $H_2O + HCl \rightarrow H_3O^+ + Cl^-$

5.

5.1 Amount of solute per unit volume of solvent.

5.2 $C = \frac{n}{V}$

$0{,}75 = \frac{n}{5}$

n = 3,75 mol

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

$c = \frac{3{,}75}{1000}$

C= 0,00375 $mol.dm^{-3}$

> **OR**
>
> $n_{before\ dilution} = n_{after\ dilution}$
>
> $c_1V_1 = c_2V_2$
>
> 0,75 (5) = C_2 (1000)
>
> C_2 = 0,00375 $moldm^{-3}$

5.3 $c = \frac{n}{V}$

$0{,}75 = \frac{n}{5}$

n= 3,75 mol

Ratio HNO_3 : $Ca(OH)_2$

2 : 1

n ($Ca(OH)_2$ = ½ (3,75) = 1,875 mol

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

$1{,}875 = \frac{m}{74}$

m = 138,75g,

Since the mass of $Ca(OH)_2$ available is less than the required mass of 138,75g , it will be insufficient

LESSON 2

SOLUTIONS

Activity 1

1.1 A

1.2.1

$$\underset{a_1}{H_2PO_4^-} + \underset{b_2}{H_2O} \leftrightarrow \underset{a_2}{H_3O^+_{(aq)}} + \underset{b_1}{HPO_4^{2-}}{}_{(aq)}$$

$$\underset{a_1}{H_2O} + \underset{b_2}{H_2PO_4^-} \leftrightarrow \underset{a_2}{H_3PO_{4\,(aq)}} + \underset{b_1}{OH^-_{(aq)}}$$

1.2.2

$$\underset{a_1}{H_2O} + \underset{b_2}{H_2O} \leftrightarrow \underset{a_2}{H_3O^+_{(aq)}} + \underset{b_1}{OH^-}{}_{(aq)}$$

Activity 2

2.1

2.1.1 NH_3, Cl^-

2.1.2 H_2O, CN^-

2.2	
2.2.1	H_2SO_4 , H_3O^+
2.2.2	H_2O, HCO_3^-

LESSON 3

SOLUTIONS

1. Define the following terms:

1.1 Strong acid- ionise completely in water to form a high concentration of H_3O^+ ions (2)

1.2 Strong base- dissociate completely in water to form a high concentration of OH^- ions. (2)

1.3 Concentrated acid- contain a large amount (number of moles) of acid in proportion to the volume of water. (2)

1.4 Dilute base- contain a small amount (number of moles) of a base in proportion to the volume of water. (2)

2 Calculate the concentration of H_3O^+ and OH^- ions in the following solutions:

2.1 NaOH of concentration 0,00001 mol.dm^{-3}

$NaOH \rightarrow Na^+ + OH^-$

Ratio 1 1 1

0,00001 0,00001 0,00001

$[OH^-] = 0,00001$ mol.dm^{-3}

$[H_3O^+][OH^-] = 1 \times 10^{-14}$

$[H_3O^+](0,00001) = 1 \times 10^{-14}$

$[H_3O^+] = 1 \times 10^{-9}$ mol.dm^{-3}

2.2 HCl of concentration 0,5 mol.dm^{-3}

$HCl \rightarrow H^+ + Cl^-$

Ratio 1 1 1

0,5 0,5 0,5

$[H_3O^+] = 0,5$ mol.dm^{-3}

$[H_3O^+][OH^-] = 1 \times 10^{-14}$

$(0,5)[OH^-] = 1 \times 10^{-14}$

$[OH^-] = 2 \times 10^{-14}$ mol.dm^{-3}

3 Calculate the pH of:

3.1 0,2 mol.dm^{-3} of HNO_3

$HNO_3 \rightarrow H^+ + NO^{3-}$

Ratio 1 1 1

0,2 0,2 0,2

$[H_3O^+] = 0,2\ mol.dm^{-3}$

$pH = -\log[H_3O^+]$
$= -\log(0,2)$
$= 0,70$

3.2 $0,04\ mol.dm^{-3}$ of H_2SO_4

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

Ratio 1 2 1

0,04 0,08 0,04

$[H_3O^+] = 2(0,04)$
$= 0.08\ mol.dm^{-3}$
$pH = -\log[H_3O^+]$
$= -\log(0,08)$
$= 1.10$

3.3 $0,2\ mol.dm^{-3}$ of $Ba(OH)_2$

$Ba(OH)_2 \rightarrow Ba^+ + 2OH^-$

Ratio 1 1 2

0,2 0,2 0,4

$[OH^-] = 0,4\ mol.dm^{-3}$

$[H_3O^+][OH^-] = 1 \times 10^{-14}$
$[H_3O^+](0,4) = 1 \times 10^{-14}$
$[H_3O^+] = 2,5 \times 10^{-14}\ mol.dm^{-3}$

$pH = -\log[H_3O^+]$
$= -\log(2,5 \times 10^{-14})$
$= 13,6$

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

$3 = -\log[H_3O^+]$

$[H_3O^+] = 0,001\ mol.dm^{-3}$

5 $pH = -\log[H_3O^+]$
$4,92 = -\log[H_3O^+]$
$[H_3O^+] = 1.2023\times10^{-5}\ moldm^{-3}$

. $H_3PO_4 \rightarrow 3H^+ + PO_4^{3-}$
1 : 3

$[H_3PO_4] = \frac{1}{3}[H^+]$
$= \frac{1}{3}(1,2023\times10^{-5})$
$= 4,0075\times10^{-6}\ mol.dm^{-3}$

LESSON 4

ACTIVITY SOLUTIONS

1. **Define the following terms:**

1.1 Strong acid- ionise completely in water to form a high concentration of H_3O^+ ions (2)

1.2 Strong base- dissociate completely in water to form a high concentration of OH^- ions. (2)

1.3 Concentrated acid- contain a large amount (number of moles) of acid in proportion to the volume of water. (2)

1.4 Dilute base- contain a small amount (number of moles) of a base in proportion to the volume of water. (2)

2 Calculate the concentration of H_3O^+ and OH^- ions in the following solutions:

2.1 NaOH of concentration 0,00001 $mol.dm^{-3}$ (4)

$NaOH \longrightarrow Na^+ + OH^-$

Ratio 1 1 1

0,00001 0,00001 0,00001

$[OH^-] = 0,00001\ mol.dm^{-3}$

$[H_3O^+][OH^-] = 1 \times 10^{-14}$

$[H_3O^+](0,00001) = 1 \times 10^{-14}$

$[H_3O^+] = 1 \times 10^{-9}\ mol.dm^{-3}$

2.2 HCl of concentration 0,5 $mol.dm^{-3}$ (4)

$HCl \longrightarrow H^+ + Cl^-$

Ratio 1 1 1

0,5 0,5 0,5

$[H_3O^+] = 0,5\ mol.dm^{-3}$

$[H_3O^+][OH^-] = 1 \times 10^{-14}$

$(0,5)[OH^-] = 1 \times 10^{-14}$

$[OH^-] = 2 \times 10^{-14}\ mol.dm^{-3}$

3 Calculate the pH of:

3.1 0,2 $mol.dm^{-3}$ of HNO_3

$HNO_3 \longrightarrow H^+ + NO^{3-}$

Ratio 1 1 1

0,2 0,2 0,2

$[H_3O^+] = 0,2$ mol.dm^{-3}

pH = - log$[H_3O^+]$
= - log(0,2)
= 0,70

3.2 0,04 mol.dm^{-3} of H_2SO_4

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

Ratio 1 2 1

0,04 0,08 0,04

$[H_3O^+] = 2(0,04)$
= 0.08 mol.dm^{-3}

pH = - log$[H_3O^+]$
= - log(0,08)
= 1.10

3.3 0,2 mol.dm^{-3} of $Ba(OH)_2$

$Ba(OH)_2 \rightarrow Ba^+ + 2OH^-$

Ratio 1 1 2

0,2 0,2 0,4

$[OH^-]$ = 0,4 mol.dm^{-3}

$[H_3O^+][OH^-] = 1 X 10^{-14}$
$[H_3O^+](0,4) = 1 X 10^{-14}$
$[H_3O^+] = 2,5 x 10^{-14}$ mol.dm^{-3}

pH = - log$[H_3O^+]$
= - log$(2,5 x 10^{-14})$
= 13,6

LESSON 4

HOMEWORK/CLASSWORK ACTIVITY

1 Define the term End point (2)

A stage of titration where the indicator changes the colour

2 45 cm^3 of sodium hydroxide solution is pipetted into a conical flask and titrated with a 0,12 mol·dm^{-3} oxalic acid ($H_2C_2O_4$). Using a suitable indicator, it was found that 20,3 cm^3 of acid was needed to neutralise the base.

$2NaOH + H_2C_2O_4 \rightarrow Na_2C_2O_4 + 2H_2O$

2.1 Write down the name an indicator that would be suitable for the above titration. Give a reason for your answer (3)

Phenolphthalein

Reaction between weak acid and strong base

pH range of Phenolphthalein is between 8,3 – 10

2.2 How many grams of oxalic acid is necessary to make $150cm^3$ of standard solution, (4)

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

$0,12 = \frac{n}{0,15}$ OR $c = \frac{m}{MV}$

n = 0,018 mol

$0,018 = \frac{m}{90}$ $0,12 = \frac{m}{90x0,15}$

m = 1,62g m= 1,62g

2.3 Calculate the concentration of the sodium hydroxide solution. (4)

$\frac{Ca.Va}{Cb.Vb} = \frac{na}{nb}$

$\frac{0,12\ x\ 20,3}{Cb\ x\ 45} = \frac{1}{2}$

Cb = 0,108 $mol.dm^{-3}$

3 A learner accidentally spills some sulphuric acid of concentration $6mol{\cdot}dm^{-3}$ from a flask on the laboratory bench. Her teacher tells her to neutralise the spilled acid by sprinkling sodium hydrogen carbonate powder onto it. The reaction that takes place is: (Assume that the H_2SO_4 ionises completely.)

$H_2SO_4(aq) + 2NaHCO_3(s) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell) + 2CO_2(g)$

The fizzing, due to the formation of carbon dioxide, stops after the learner has added 27 g sodium hydrogen carbonate to the spilled acid.

3.1 Calculate the volume of sulphuric acid that spilled. Assume that all the sodium hydrogen carbonate reacts with all the acid. (6)

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

$n = \frac{27}{84}$

n = 0,32 mol

n(H2SO4) = ½ (0,32) = 0,16 mol

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

$6 = \frac{0,16}{V}$

V = 0,027 dm^3

The learner now dilutes some of the 6 mol·dm^{-3} sulphuric acid solution in the flask to 0,1 mol·dm^{-3}.

3.2 Calculate the volume of the 6 mol·dm^{-3} sulphuric acid solution needed to prepare 1 dm^{3} of the dilute acid. (2)

Ca.Va = Cb.Vb

6. Va = 0,1 . 1

Va = 0,017 dm^{3}

4 During a titration 25 cm^{3} of the 0,1 mol·dm^{-3} sulphuric acid solution is added to an Erlenmeyer flask and titrated with a 0,1 mol·dm^{-3} sodium hydroxide solution.

Calculate the pH of the solution in the flask after the addition of 30 cm^{3} of sodium hydroxide. The endpoint of the titration is not yet reached at this point (8)

For the acid

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

$0,1 = \frac{n}{0,025}$

n = 0,0025mol

For the base that reacted

$0,1 = \frac{n}{0,03}$

n = 0,003m0l

Ratio of Acid : Base

1 : 2

n (acid) = ½ n (base) = ½ 0,003 = 0,0015 mol

n (acid unreacted) = n (initial) – n (reacted)

= 0,0025 – 0,0015 = 0,001 mol

$c = \frac{n}{V}$ Actual volume = 25 + 30 = 55 cm^{3}

$c = \frac{0,001}{0,055}$

C = 0,018 mol.dm^{-3}

pH = -log [H3O+]

= - log (2 x 0,018)

= 1,44

LESSON 5

CLASSWORK EXERCISE

1.Write down ionic equations for the hydrolysis reaction for the following salts

1.1 $Na_2CO_3 + H_2O \rightarrow$

$CO_3^{2-} + H_2O \rightarrow HCO_3^{-} + OH^{-}$ **BASIC SOLUTION**

1.2 $CH_3COONa + H_2O \rightarrow$

$CH_3COO^- + H_2O \rightarrow CH_3COOH + OH^-$ **BASIC SOLUTION**

1.3 $NaHCO_3 + H_2O \rightarrow$

$HCO_3^- + H_2O \rightarrow H_2CO_3 + OH^-$ **BASIC SOLUTION**

1.4. $KCl + H_2O \rightarrow$

$Cl^- + H_2O \rightarrow 1HCl + 1OH^-$ **NEUTRAL SALT**

1.5 $NaCN + H_2O \rightarrow$

$CN^- + H_2O \rightarrow HCN + OH^-$ **BASIC SOLUTION**

1.6 $(NH_4)_2SO_4 + H_2O \rightarrow$

$NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$ **ACIDIC SOLUTION**

SOLUTIONS
1.1.1 A
1.2.1 Fertilizers replenish nutrients depleted by the growing of crops.
1.2.2 Damage to crops /soil resulting in small or no harvest/ less income.
Excessive fertilizer seeps into groundwater and contaminates drinking water (any Runs into rivers and / or dams and causes eutrophication.
1.2.3 Enhance growth of crops/ plants to produce more food for humans
Food security for humans
Production / application of fertilizer results in job creation selling fertilizers
Stimulates the economy (any one)

2.1			
	2.1.1	The ratio of Nitrogen(N), Phosphorus (P) and potassium (K) in the certain fertilizer	
	2.1.2	Percentage fertiliser in the bag	
	2.1.3	% K= 5/12x 22%=9,17 % m(N)=9,17/100x 10kg =0,92 kg	
2.2			
	2.2.1	% P= 3/7x 22%=9,43% m (P) =9,43/100 x 2%= 0,19kg	
2.3			
	2.3.1	Total percentage of fertilizer	
	2.3.2	Mass of fertilizer in P =25/100 x50 kg = 12,5 kg Mass of fertilizer in Q = 20/100 x 50kg =10kg Amount of potassium in Q =3/10 x12,5 kg =3,75 kg Amount of potassium in Q =4/8 x 10 kg=5 kg Fertiliser Q has more potassium per mass than fertilizer P	
2.4			
	2.4.1	NH_4NO_3 : 80g---- 28g N 20kg …… 28/80 x 20 m (N) = 7 kg Na_3PO_4 : 164g….. 31 g P 12 kg …….31/164 x12 m (P) =2,27 kg KCl : 74,5 g……. 39g K 18 kg …… 39/74,5 x18 m (K) =9,42 kg N:P: K 7:2,27:9,42 3:1:4	

SOLUTIONS WORKSHEET 3
1.1.1 Ostwald process
1.1.2 Catalyst/ speed up the rate of reaction
1.1.3 Nitrogen dioxide
1.1.4 $3NO_2 + H_2O \longrightarrow 2HNO_3(aq) + NO$
1.1.5 Decrease pressure
Increase volume
Decrease temperature

1.2.1 2-4-3-1
1.2.2 $2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$
1.2.3Vanadium pentoxide
1.2.4 $SO_3(g) + H_2SO_4 \longrightarrow H_2S_2O_7$
1.2.5 Sulphuric acid will form (white) mist.
The reaction is very exothermic/ gives off too much heat

		SOLUTION (LESSON 3) ACTIVITY 2
2.2.1.		
	2.1.1	
	2.2.1.1	B & C
	2.2.1.2	Nitric Acid /HNO3
	2.2.1.3	A
	2.2.1.4	$2NH_3(g) + H_2SO \rightarrow (NH_4)_2SO_4$
	2.2.1.5	D

SOLUTIONS FOR REVISION QUESTIONS
QUESTION 1

1.1.1 $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ Bal (3)

1.1.2 Catalyst OR Increase the reaction rate (1)

1.2 Exothermic. The temperature increases (2)
1.3 An exothermic reaction is favoured by a decrease in temperature.
The forward reaction is favoured.
Higher yield (of SO_3). (3)
1.4.1 $H_2S_2O_7$ (1)
1.4.2 A mist will form (which is difficult to collect). **OR** The reaction is too exothermic. (1)
1.5 $H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$ (3)

[14]

QUESTION 2

2.1.1 Haber process. (1)
2.1.2 $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (3)
2.1.3 Air (1)
2.2.1 40% (1)
2.2.2 High yield and high rate due to higher concentration. (2)
2.2.3 Low reaction rate. (1)
2.3 **OPTION 1**
% N in NH_4NO_3= $\frac{28}{80} \times 100 = 35\%$
m(N) in 50 kg:= $\frac{35}{100} \times 50 = 17.5\ kg$
OPTION 2
M(N) in NH_4NO_3 = $\frac{28}{80} \times 50 = 17.5\ kg$ (3)

QUESTION 3
3.1.1 Air (1)
3.1.2 Natural gas / methane / oil / coal (1)
3.1.3 Sulphur / iron pyrite / iron sulphide (1)
3.2.1 Haber process (1)
3.2.2 Ammonia (1)
3.2.3 H_2SO_4 (1)

3.2.4 $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ (3)
3.3.1 %N[NH_4NO_3] =28/80 x 100 = 35%

%N[$(NH_4)_2SO_4$] = 28/132 x 100 = 21,21%

Ammonium nitrate (has the highest percentage of nitrogen). (4)
3.3.2 Ostwald process (1)
[14]

4.1 Percentage of fertiliser (N, P and K) present in the fertiliser.
4.2
4.2.1 A
4.2.2 C
4.2.3 C
4.3
4.3.1 %N = 3/6 x 28= 14% (2)

4.2.2

OPTION 1 22% of 20 kg = 4,4 kg 4/9x 4,4 = 1,96 kg	**OPTION 2** 4/9 x 22 = 9,78% 9,78% of 20 kg = 1,96 kg
OPTION 3 22% of 20 kg = 4,4 kg 44,44% of 4,4 = 1,96 kg	

4.4 $H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$

ACTIVITY 5

5.1 Vanadium pentoxide (1)
5.2 $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (3)
5.3 22% of 5 kg = 1, 1 kg
7/11 x 1, 1 = 0,7 kg = 700 g
n=m/M = 700/14= 50 moles (5)
5.4 Excess plants block sunlight from aquatic life and organisms die. /Lack of oxygen. (1)
[10]