Module 2

Q1 Balance the following chemical equations.

(a) $H_3AsO_4 \rightarrow As_2O_5 + H_2O$
(b) $C_{10}H_{16} + Cl_2 \rightarrow C + HCl$
(c) $K + Br_2 \rightarrow KBr$
(d) $Al + HCl \rightarrow AlCl_3 + H_2$
(e) $FeCl_3 + NH_4OH \rightarrow Fe(OH)_3 + NH_4Cl$
(f) $Li_2O + H_2O \rightarrow LiOH$
(g) $SiC + Cl_2 \rightarrow SiCl_4 + C$
(h) $V_2O_5 + HCl \rightarrow VOCl_3 + H_2O$
(i) $S_8 + O_2 \rightarrow SO_3$
(j) $KClO_3 \rightarrow KCl + O_2$

Q2 Complete the following table.

	Chemical	Chemical Formulae	Elements Present	A_r / M_r Calculation	A_r / M_r
E.g.	Hydrated Copper (II) Sulphate	$CuSO_4 \bullet 5H_2O$	1 Cu, 1 S, 10 O, 10 H	64 + 32 + (16 x 4) + 5 x [(2 x 1 + 16)] = 250	250
1	Nitrogen gas				
2		Pb			
3			2 I		254
7	Barium Sulphate				
8		$CaSO_4$			
16	Sulphurous Acid				
19	Monosodium Glutamate	$C_5H_8NNaO_4$			

5078 Science (Chemistry & Biology)
Module 2: Equations & Stoichiometry

Q3 Melatonin ($C_{13}H_{16}N_2O_2$) is a naturally occurring compound found in living things. They are often used to alleviate the problem of headache or insomnia.

(a) Calculate the relative formula mass of melatonin.

Melatonin are usually excreted from the body through urination. Urine is an aqueous solution that comprises of mainly water, urea and other compounds in marginal quantity.

Urea, as an organic compound, can be acquired through reacting Silver Isocyanate (AgNCO) together with ammonium chloride.

$$AgNCO + NH_4Cl \rightarrow (NH_2)_2CO + AgCl$$

(b) Calculate the mass of ammonium chloride required to react with 55 g of silver isocyanate.

Q4 Sulphuric acid and sodium hydroxide can react as follows:

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(a) Use the relative atomic masses to calculate the relative molecular mass of sodium hydroxide.

(b) (i) Calculate the mass of sodium sulphate that could be formed from 40 g of sodium hydroxide?

(ii) How many atoms of sodium sulphate is present in this reaction?

Q5 Octane (C_8H_{18}) is a molecule in petrol. Octane undergoes complete combustion according to the following equation.

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

Calculate the mass of octane required to react with 320 kg of oxygen.

Q6 Hydrogen peroxide, commonly found in bleaches, decomposes itself into water and oxygen. The reaction is sped up with Manganese (IV) oxide, a catalyst. The equation of the reaction is as follow.

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

Calculate the mass of oxygen obtained from the decomposition process of 680 g of hydrogen peroxide.

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Module 2: Equations & Stoichiometry

Q7 What mass of carbon dioxide is formed when 20 g of calcium carbonate reacts with hydrochloric acid?

$$CaCO_3 + 2\,HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Q8* Rubidium hydroxide is a very strong chemicals that are rarely used in industrial processes. The compound is a result of dissolving rubidium oxide in water.

(i) Write a chemical equation to represent this reaction, with state symbols.

(ii) Draw a 'dot and cross' diagram to represent rubidium oxide. Show only the valence shell.

(iii) With the aid of a suitable illustration, explain why rubidium hydroxide have higher volatility than oxygen gas.

(iv) Explain what happens when rubidium oxide reacts with water, in terms of particles.

(iv) A team of chemical engineer reacted 10 tonnes of rubidium oxide with water. Determine the amount of rubidium hydroxide obtainable from this process, in atoms.

(v) Propose a method to decompose rubidium hydroxide.

Module 2 (Solutions)

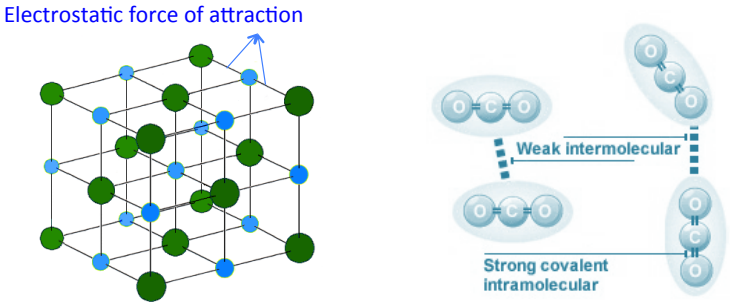
Q2 Complete the following table.

	Chemical	Chemical Formulae	Elements Present	A_r / M_r Calculation	A_r / M_r
E.g.	Hydrated Copper (II) Sulphate	$CuSO_4 \bullet 5H_2O$	1 Cu, 1 S, 10 O, 10 H	64 + 32 + (16 x 4) + 5 x [(2 x 1 + 16)] = 250	250
1	Nitrogen gas	N_2	2N	14 x 2 = 28	28
2	Lead	Pb	1 Pb	207	207
3	Iodine	I_2	2 I	127 x 2 = 254	254
7	Barium Sulphate	$BaSO_4$	1Ba, 1S, 4O	137 + 32 + (16 x 4) = 213	233
8	Calcium Sulfate	$CaSO_4$	1Ca,1S,4O	40 + 32 + (16 x 4) = 138	136
16	Sulphurous Acid	H_2SO_3	2H,1S,3O	(1x2)+32+(16x4) = 98	98
19	Monosodium Glutamate	$C_5H_8NNaO_4$	5C,8H,1N,1Na,4O	(12x5)+(1x8)+14+23+(16x4) = 169	169

Q8 **(ii)** Draw a 'dot and cross' diagram to represent rubidium oxide. Show only the valence shell.

- Legends of the electrons must be provided. Dots and cross are properly drawn on the valence shell of atoms.
- Atomic size of Rb must be larger than O and Rb^+, while the atomic size of Rb^+ must be larger than O. This is because Rb has a higher period number than O and Rb^+!
- Only valence electrons are shown!

(iii) With the aid of a suitable illustration, explain why rubidium hydroxide have higher volatility than oxygen gas.



Large amount of energy is required to overcome the electrostatic force of attraction between the Rb^+, H^+ and O^{2-} ions in the giant lattice structure. On the other hand, the Van der Waals forces between the molecules of oxygen are very weak, little energy is needed to overcome them. Hence, RbOH has higher volatility than oxygen gas.

(iv) Explain what happens when rubidium oxide reacts with water, in terms of particles.

- As RbO reacts with water, the electrostatic attraction weakens as the water molecules had distrupt the giant lattice structure.
- As a result, the RbO particles no longer get confined at their fixed position but begin to move around and collide with the water molecules.
- Hence, RbOH is gradually formed during the effective collisions.

Part (iv) requires an explanation from three chapters - Ionic Bonding, Kinetic Particle Theories and Collision theory.

Module 2.

Q1) (a) $2H_3AsO_4 \rightarrow As_2O_5 + 3H_2O$ → simpler molecule

H - 6	H - 6
As - 2	As - 2
O - 8	O - 8

$2H_3AsO_4 \Rightarrow As_2O_5 + 3H_2O$.

(b) $C_{10}H_{16} + 8Cl_2 \rightarrow 10C + 16HCl$

H - 16	C - 10 ✓
C - 10 ✓	H - 16
Cl - 2	Cl - 16

① 1st balance C.
↓
balance H
↓
balance Cl_2.

$\therefore C_{10}H_{16} + 8Cl_2 \rightarrow 10C + 16HCl$

(c) $2K + Br_2 \rightarrow KBr$.

(d) $Al + 6HCl \rightarrow AlCl_3 + H_2$.

(e) $FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3 + 3NH_4Cl$

(f) $Li_2O + H_2O \rightarrow 2LiOH$.

(g) $SiC + 2Cl_2 \rightarrow SiCl_4 + C$

(h) $V_2O_5 + 6HCl \rightarrow 2VOCl_3 + 3H_2O$

V - 2	V - 2
O - 5	O - 5
H - 6	H - 6
Cl - 6	Cl - 6

① balance H
② find common multiple b/w Cl = 6
③ balance V
④ Balance H & O.

(i) $S_8 + 12O_2 \rightarrow 8SO_3$.

(j) $2KClO_3 \rightarrow 2KCl + 3O_2$.

Q3. (a) 232 g/mol

(b)

	Mr	mass	
AgNCO	~~149~~ 150	55g	} 1:1 relation.
* NH_4Cl	53.5	?	

mol of AgOCN = $\frac{55}{150}$ * $\frac{mass}{Mr}$ = $\frac{55}{150}$ = 0.367 mol

∴ mol of AgOCN = mol of NH_4Cl

∴ mass of NH_4Cl = 0.367 × 53.5

= 19.6 g # (3sf).

Q4. (a) 40 g/mol.

(b i)

	Mr	mass	
NaOH	40 g/mol	40g	→ 2 mol
Na_2SO_4	144	x	→ 1 mol

∴ mol of NaOH = ~~1~~ 2 mols

mol of Na_2SO_4 = 1/2 mol

mass = mol × Mr = 1/2 × 144 = 72g #

Q5.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

	Mr	mass		
O_2	32g	320000g = 320 kg	→ 25 mol	} ÷ 12.5 mol
C_8H_{18}	114g	x g	= 2 mol	

mol of O_2 = $\frac{320000}{32}$ = 10000 mol

mol of C_8H_{18} = $\frac{10000}{12.5}$ = 800 mol

mass = mol × Mr = 800 × 114 ÷ 1000

= 91.2 kg #

Q6.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

	Mr	mass	
H_2O_2	34	680g	} 2:1
O_2	32	x g	

mol of H_2O_2 = $\frac{mass}{Mr}$ = $\frac{680}{34}$ = 20 mol

mol of O_2 = $\frac{20}{2}$ = 10 mol

mass of O_2 = 10 × 32 = 320g #

Q7

	Mr	mass	
CO_2	44	x	→ 1 mol
$CaCO_3$	100	20g	→ 1 mol

mol of $CaCO_3$ = $\frac{mass}{Mr} = \frac{20}{100} = 0.2$ mol

mol of $CaCO_3$ = mol of CO_2 = 0.2 mol

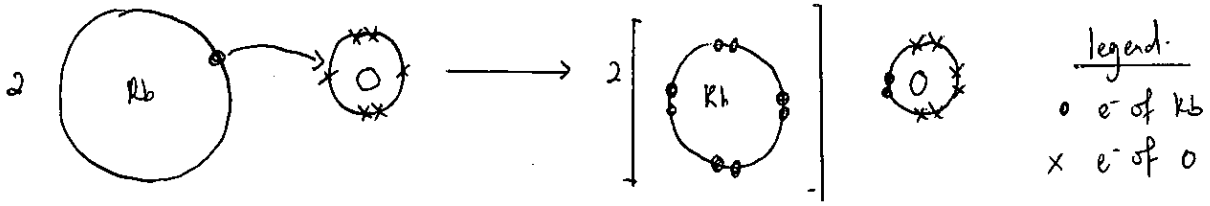
∴ mass of CO_2 = $0.2 \times 44 = \underline{8.8g}$ #

Q8

~~Rb_2O (s) + H_2O (l) → $2RbOH_2$ (aq)~~

(a) Rb_2O (s) + H_2O (l) → $2RbOH$ (aq)

(b) Rb_2O.



Rubidium oxide

legend:
- • e⁻ of Rb
- × e⁻ of O

(c)

(c)(iv)

	Mr	mass	
Rb_2O	186.94	10 tonnes	1
RbOH	102.48	?	2

mole of Rb_2O = $\frac{10 \times 1000 \times 1000}{186.94} = 53493$ mol

RbOH: 53.493×2 = ~~106.99 mol~~ 106986 mol

mass = mol × Mr = 106986×102.48

= ~~1096 g~~ 10963952.28 g

(v) ~~Therm~~ Electrolysis.

= $\underline{1096 \text{ tons}}$ #