Mark Scheme

Paper 2 Theory
Section A

1 **(a)** **(i)** CH_4 / CO_2 [1]

(ii) CO_2 [1]

(iii) Ar [1]

(iv) Cl_2 [1]

(v) Al^{3+} [1]

(vi) O^{2-} [1]

(b) acidic oxide: any non-metal oxides (except H_2O, NO, CO) [1]
It **reacts with alkalis** to **form salt and water**. / It **dissolves in water** to **form acids**.

neutral oxide: H_2O, NO, CO [1]
It **does not react with acids or alkalis**.

2 **(a)** $NH_3 + HCl \rightleftharpoons NH_4Cl$ [1]

(b)

Universal Indicator paper	colour	pH
1	**blue / indigo**	**11 / 12**
2	**red**	**1 / 2 / 3**

[1]

[1]

(c) • **Ammonia (M_r = 17) has a lower relative molecular mass than hydrogen chloride (M_r = 36.5)** [1]

• hence it would **diffuse faster** [1]

• and the **white powder forms closer** to the cotton wool soaked in **concentrated hydrochloric acid**. [1]

3 **(a)** • similarity: **good conductors of electricity / good conductors of heat / malleable** [1]

• difference: sodium has a **low melting point** while niobium has a **high melting point** / sodium has a **low density** while niobium has a **high density** / sodium is **soft** and can be easily cut with a knife while niobium is **hard** / sodium forms **compounds that are white in colour** while niobium forms **coloured compounds** / sodium has a **fixed oxidation state** while niobium has a **variable oxidation state** [1]

(b) **(i)** Niobium is a **transition metal** hence it **should** react with chlorine to **form an ionic compound with a giant ionic lattice structure** however, it **formed a covalent molecule with a simple molecular structure** instead. [1]

(ii) $NbCl_5$ [1]

(c) Sodium chloride:

- Sodium chloride is an **ionic** compound with a **giant ionic lattice structure**. [3]
- **A lot of energy** is required to **overcome strong electrostatic forces of attraction** between **oppositely charged sodium ions and chloride ions**.
- Hence, sodium chloride has a **high boiling point**.

Niobium chloride:

- Niobium(V) chloride is a **covalent** compound with a **simple molecular structure**.
- **Little energy** is required to overcome **weak intermolecular forces of attraction between niobium(V) chloride molecules**.
- Hence, niobium(V) chloride has a **low boiling point**.

[1] - correct structure and bonding
[1] – correct amount of energy and description of bonding
[1] – correct comparison of boiling point

4 (a) (i) At –10°C, chlorine exists as a gas.

- Chlorine molecules are **very far apart in a random arrangement** [1]
- and they **move freely / in all directions at high speeds**. [1]

(ii)
- The **relative molecular mass of chlorine is 71** whereas the **relative molecular mass of bromine is 160**. The relative molecular mass of bromine is **nearly double** the relative molecular mass of chlorine. However, the **density** of bromine is **nearly a hundred times more** than the density of chlorine. [1]
- The **volume** of the two substances needs to also be **considered** to account for the differences in densities. [1]

(b) (i)
- **Fluorine / chlorine**, [1]
- being **more reactive** than bromine, can **displace bromine from potassium bromide** to form **potassium fluoride / potassium chloride and bromine**. [1]
- Solution turns from **colourless to red-brown**. [1]
- $F_2 + 2Br^- \rightarrow 2F^- + Br_2$ / $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$ [1]

(ii)
- test: **Add dilute nitric acid and aqueous silver nitrate** into seawater. [1]
- observation: A **yellow precipitate** is observed if iodide ions are present. [1]

5 (a) All the dyes must have **different solubilities** in the **same solvent / a mixture of water and ethanol**. [1]

(b)
- The **R_f value for the yellow dye in pure water / 100% water / 0% by volume of ethanol is zero**, which implies that the **yellow dye is insoluble in pure water**. [1]
- The **R_f value for the red dye in pure ethanol / 100% ethanol / 0% by volume of water is zero**, which implies that the **red dye is insoluble in pure ethanol**. [1]
- The **black dye would not be completely separated** into its components if either pure water or pure ethanol is used / **the results of the separation would be affected**. [1]

(c) Percentage of ethanol = $\frac{32}{200} \times 100\%$
$= 16\ \%$ [1]

Hence, R_f value of blue dye is **0.72**. [1]

(d) **(i)** No, he cannot conclude that the black dye is a pure substance.
- The **R_f value of the blue, red and yellow dye is the same at 0.4** [1]
- when there is **80% ethanol as solvent**, hence the student only observed one spot when the black dye is actually a mixture of blue, red and yellow dyes. [1]

(ii)
- The **start line** must be **drawn using a pencil**. [1]
- The **level of solvent** must be **below the start line**. [1]

6 **(a)**
- Comparing experiments 1 and 3, when the **concentration of Br^-** in **experiment 3** at 2.00 mol/dm^3 is **twice** that of **experiment 1** at 1.00 mol/dm^3, the **initial rate of reaction** in experiment 3 at 0.032 moldm^{-3}/s was **four times** the initial rate of reaction in experiment 1 at 0.008 moldm^{-3}/s. [1]
- Comparing experiments 2 and 4, when the **concentration of H^+** in **experiment 4** at 2.00 mol/dm^3 is **twice** that of **experiment 2** at 1.00 mol/dm^3, the **initial rate of reaction** in experiment 4 at 0.032 moldm^{-3}/s was **twice** the initial rate of reaction in experiment 2 at 0.016 moldm^{-3}/s. [1]

(b)
- As the **concentration increases**, there are **more particles per unit volume**. [1]
- This **increases the frequency of effective collisions between reacting particles**, resulting in an **increase in the initial rate of reaction**. [1]

(c) **(i)**

species	BrO_3^-	Br^-	Br_2
oxidation state	**+5**	**–1**	**0**

[2]

[1] – 2 correct
[2] – all correct

(ii)
- The **oxidation state of Br decreases from +5 in BrO_3^- to 0 in Br_2**, hence **reduction** occurred. [1]
- The **oxidation state of Br increases from –1 in Br^- to 0 in Br_2**, hence **oxidation** occurred. [1]

This reaction is a disproportionation reaction as Br is simultaneously reduced and oxidised in a single reaction.

7 (a) (i) gain in mass at cathode = loss in mass at anode [1]
= 1.44 – 1.20
= **0.24 g**

mass of anode after electrolysis [1]
= 1.45 – 0.24
= **1.21 g**

(ii) gain in mass at cathode after electrolysis at 8.0A for 90 s = gain in mass at cathode after electrolysis at 4.0A for 180 s [1]
= 0.24 g

mass at cathode
= 1.51 + 0.24
= **1.75 g**

(iii) [3]

electrode	anode	cathode	electrolyte
carbon	observation: **effervescence** of a colourless (odourless) gas / size of anode remains the same explanation: **hydroxide ions are selectively discharged** at the anode and are **oxidised to form oxygen gas**	observation: **pink-brown solid forms** at the cathode / cathode increases in size explanation: **copper is less reactive than hydrogen** hence **copper(II) ions are selectively discharged** at the cathode and are **reduced to form copper metal**	observation: **blue solution fades** / turns light blue / becomes colourless *OR* becomes acidic explanation: there is a **net loss of copper(II) ions**, **concentration of copper(II) ions decreases** *OR* **hydroxide ions are selectively discharged to form oxygen gas; less hydroxides ions**

[1] – correct observation and explanation for anode
[1] – correct observation and explanation for cathode
[1] – correct observation and explanation for electrolyte

(b) **(i)** most reactive **C** [1]
B
A
copper
least reactive **D**

(ii) • The **greater the voltage**, the **greater the potential difference** hence the **greater the difference in reactivity of metals**. [1]

• When the **voltage is negative**, **copper** loses the electrons instead hence it is **more reactive** than metal D. [1]

8 **(a)** $Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$ [2]

[1] – correct balanced equation
[1] – correct state symbols

(b) The **limiting reagent, aqueous barium hydroxide,** has **completely reacted**. [1]

(c) Number of moles of $H_2SO_4 = \frac{2.5}{1000} \times 1.0$ [1]
$= 0.0025$ mol

By mole ratio, [1]

H_2SO_4	:	$Ba(OH)_2$
1	:	1
0.0025	:	0.0025

Concentration of $Ba(OH)_2 = \frac{0.0025}{\frac{5}{1000}}$ [1]
$= 0.5$ mol/dm^3

OR

$M_1V_1 = M_2V_2$ [3]
$1.00(2.5) = M_2(5)$
$M_2 = 0.5$ mol/dm^3

(d) • The electrical conductivity **decreases from W to X** as **more solid barium sulfate is formed as sulfuric acid is being added**, **less ions** present to carry electrical charges. [1]

• The electrical conductivity is the **lowest at X** as **complete neutralisation** occurred / **all barium hydroxide has reacted with sulfuric acid** hence **least ions** present to carry electrical charges. [1]

• The electrical conductivity **increases from X to Y** as **excess sulfuric acid is added** after complete neutralisation hence there are **more ions** present to carry electrical charges. [1]

(e) **Use of pH meter** to monitor **changes in pH / Use of thermometer to monitor changes in temoperature** [1]

(f) Student 2 is correct.

[1]

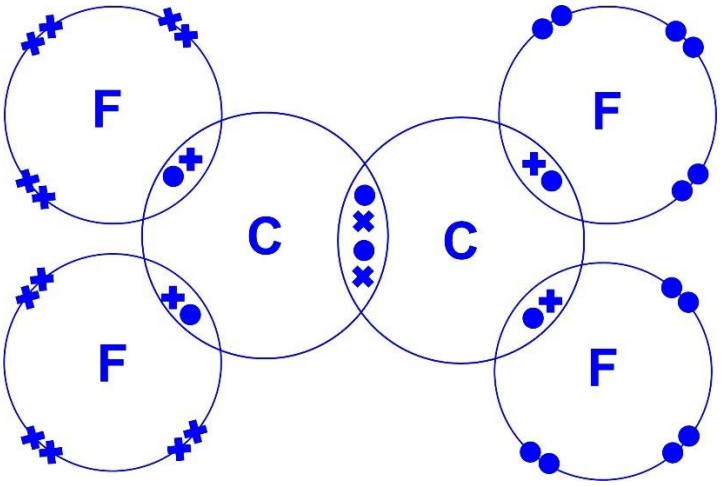
- If barium carbonate is used, an **insoluble layer of barium sulfate will form over insoluble barium carbonate and prevent further reaction**.

[1]

- **Barium nitrate is soluble** hence barium nitrate could be used to prepare an insoluble salt.

Section B

9 (a)



[2]

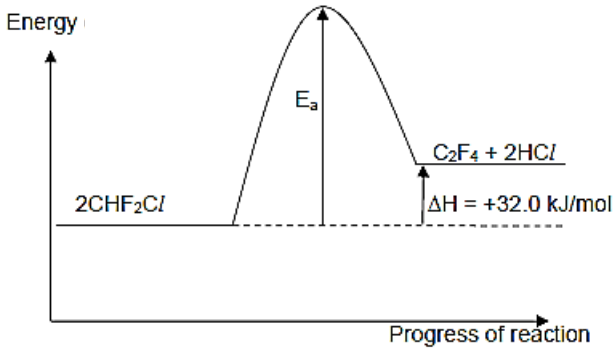
[1] – correct sharing
[1] – correct electronic structures

(b) Energy absorbed during bond breaking = 2(339) + 4(495) + 2(413) [1]
= 3484 kJ

Energy released during bond forming = x + 4(495) + 2(431) [1]
= (x + 2842) kJ

ΔH = 3848 – (x + 2842) [1]
32 = 642 – x
x = 610 kJ/mol

(c)



[3]

[1] – correct reactants and products
[1] – correct E_a
[1] – correct ΔH

(d) test: **Bubble chlorodifluoromethane and tetrafluoroethene through aqueous bromine** in separate test-tubes. [1]

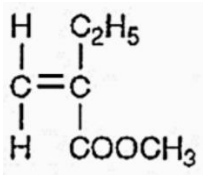
observation: **Aqueous bromine remains red-brown** in chlorodifluoromethane while **aqueous bromine turns from red-brown to colourless / decolourises** in tetrafluoroethene. [1]

10 **(a)**

- Addition polymers are made up of only **one type of monomer** while condensation polymers are made up of **two or more types of monomers**. [2]
- The formation of addition polymers **does not involve the elimination of a small molecule** while the formation of condensation **involves the elimination of a small molecule**.
- **Only one product** is formed during the formation of addition polymers while **two products** are formed during the formation of condensation polymers.

any 2

(b) **(i)** [1]



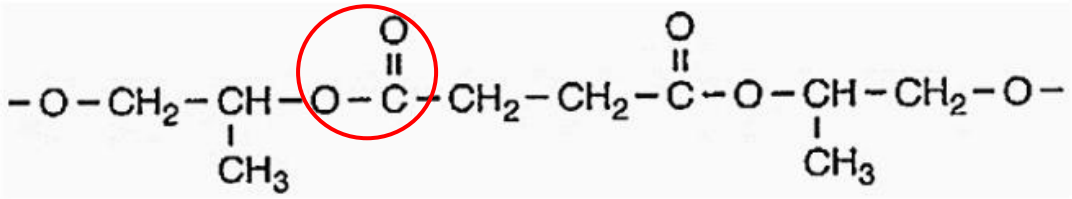
(ii) M_r of repeat unit = 6(12) + 10(1) + 2(16) [1]
= 114

Number of repeat units = $\frac{20000}{114}$ [1]
= 175.43

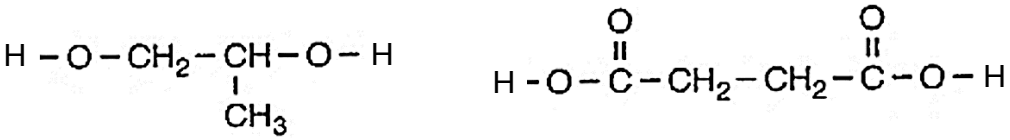
Number of repeat units = $\frac{50000}{114}$
= 438.59

Range of average number of repeat units = 176 to 439

(c) **(i)** [1]



(ii) [2]



(d) **(i)** Polymers are **non-biodegradable** hence they would **fill up landfills** and **cause land pollution** / become **marine trash** and **cause water pollution** / **release toxic gases when burnt** causing **air pollution**. [1]

(ii) **Cracking / depolymerisation** can be carried out on the polymers to **form back the monomers**. [1]