St. Joseph's Institution
2022 Year 4 OP Preliminary Exam Answer Scheme

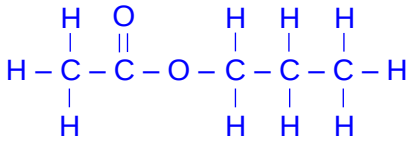
Paper 1

1	2	3	4	5	6	7	8	9	10
B	D	B	C	C	C	C	D	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	D	C	A	A	C	C	B	A	D
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
D	A	C	D	A	B	B	C	B	B
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
A	B	A	A	D	A	A	B	B	C

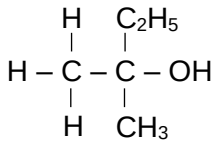
Paper 2 Section A

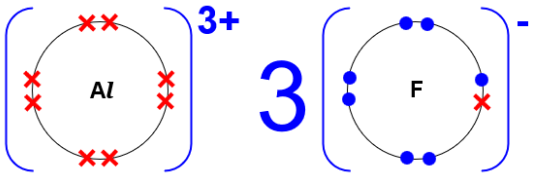
Qn	Suggested answers	Mark
A1a	**W:** iron / Fe **X:** zinc sulfate / $ZnSO_4$ **Y:** barium sulfate / $BaSO_4$	1 1 1
A1b	Lighted splint extinguishes with a pop sound.	1
	TOTAL	**4**
A2ai	The **rate of reaction increases**. When temperature increases, the reacting particles have **higher kinetic energy**, move faster and collide more often. **More particles have energy equal to or higher than the activation energy**. Thus, the **frequency of effective collisions between reacting particles increases**. [every 2 points – 1m]	2
A2aii	No. Increasing the pressure has **no effect on liquids** as the particles in liquids are closely packed.	1
A2bi	No. of moles of Si_2OCl_6 = 1 / 285 = 0.0035088 mol No. of moles of Cl^- ions = 0.0035088 x 6 = 0.021053 = 0.0211 mol (to 3 s.f.)	 1
A2bii	No. of moles of $Si_3O_2Cl_8$ = 1 / 400 = 0.00250 mol No. of moles of Cl^- ions = 0.00250 x 8 = 0.0200 mol	 1
A2ci	$Ag^+ + Cl^- \rightarrow AgCl$	1
A2cii	No. of moles of $AgCl$ = 3.03 / 143.5 = 0.0211 mol (to 3 s.f.) Since 1 mole of $AgCl$ forms 1 mole of Cl^- ions, the oxochloride is **Si_2OCl_6** since the **number of moles of Cl^- ions are the same at 0.0211 mol.**	1 1
	TOTAL	**8**

Qn	Suggested answers	Mark
A3ai	**Nitrogen** in the air **reacts with oxygen** in the air at **high temperatures** to form nitrogen dioxide gas.	1
A3aii	Nitrogen dioxide **reacts with oxygen and moisture in the air** to form **nitric acid**. The nitric acid dissolves in rainwater to form acid rain, which **falls** to the soil. The **nitrate ions are formed from** the dissociation of **nitric acid**, causing the soil to have a high nitrate content.	1 1
A3aiii	$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$	1
A3bi	Carbon dioxide is a **greenhouse gas** which **traps excess heat**, causing **global warming**. Global warming causes ice bergs at the poles to melt, sea levels to rise and leading to floods in lowlands / causes droughts and crop yield to decrease (or any other possible answer).	1 1
A3bii	More people should **take public transport** instead of driving personal cars to **decrease carbon dioxide emissions.** This is because each **car generates much more carbon dioxide** than the bus, i.e. **5750 kg** of carbon dioxide per year as compared to **3200 kg** of carbon dioxide per year.	1 1
A3ci	**450 °C, 250 atm** and finely divided **iron catalyst**	1
A3cii	The reaction between nitrogen and hydrogen is **reversible.**	1
	TOTAL	**10**
A4a	The oxidation state of sulfur increases from -2 in ZnS to +4 in SO_2. ZnS has been oxidised / This is oxidation. The oxidation state of oxygen decreases from 0 in O_2 to -2 in ZnO. O_2 has been reduced / This is reduction. Since oxidation and reduction occurs simultaneously, this is a redox reaction.	1 1
A4b	$ZnO(s) + CO(g) \rightarrow Zn(s) + CO_2(g)$ [1m – chemical equation, 1m – state symbols]	2
A4ci	**Reddish brown solid** will be formed on the copper-coated rod **No visible reaction** on the surface of the zinc-coated rod.	1 1
A4cii	**Copper is less reactive than iron**, iron will corrode faster and **iron will rust**. **Zinc is more reactive than iron**, so **zinc will corrode in place of iron** and iron will not rust.	1 1
	TOTAL	**8**
A5a	Transition metals **form coloured compounds**. / Transition metals and their compounds are **good catalysts.**	1
A5bi	scandium and zinc	1
A5bii	Both scandium and zinc have only **one oxidation state of +3 and +2 respectively** instead of having **variable oxidation states.** Scandium has a **much lower density of 2.99 g/dm^3** as compared to the rest of the transition metals with higher densities between 4.50 g/dm^3 to 8.92 g/dm^3. Zinc has a **much lower melting point of 420 °C** as compared to the rest of the transition metals with higher melting points between 1083 °C to 1890 °C.	1 1 1
	TOTAL	**5**
A6a	Experiment 1: **copper** metal Experiment 2: **hydrogen** gas, **zinc** electrode	1 2
A6b	• Effervescence / bubbling of a colourless gas at the anode. • Reddish brown / pink solid formed at the cathode. • Size of cathode increases • Blue solution turns colourless. [any two of the above]	2
A6c	$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e$ [1m – ionic equation, 1m – state symbols]	2

Qn	Suggested answers	Mark
A6d	The gases can be dried by passing through drying agents such as **concentrated sulfuric acid / calcium oxide / calcium chloride.** The volumes of the gases can be determined by collecting them in a calibrated **gas syringe**.	1 1
	TOTAL	**9**
A7ai	A unsaturated hydrocarbon **contains** at least one **carbon-carbon (C=C) double bond**.	1
A7aii	Bubble propene gas into **aqueous bromine**. Aqueous bromine **turns from reddish brown to colourless / decolourises rapidly.**	1
A7bi	**Addition of steam** to propene **300 °C, 60 atm, phosphoric(V) acid catalyst**	1 1
A7bii	 propyl ethanoate	1 1
	TOTAL	**6**

Paper 2 Section B

Qn	Suggested answers	Mark
B8a	Butan-2-ol. There are **two alkyl groups attached to the carbon atom with hydroxyl group**.	 1
B8b		1
B8ci	As the **number of alkyl groups** attached to the carbon atom with hydroxyl group **increases**, the **boiling point decreases**.	1
B8cii	The **intermolecular forces of attraction** between the molecules become **weaker**, so **less energy** required to overcome the weaker intermolecular forces of attraction.	1
B8d	Similarity: Hydrogen is produced in both reactions. Difference: An **alkoxide** is produced in the reaction between an alcohol and sodium but a **salt** is produced in the reaction between a carboxylic acid and sodium.	1 1
B8e	As the **number of alkyl groups** attached to the carbon atom with hydroxyl group **increases**, the **acidity decreases**.	1
B8f	Ethanoic acid. It has the **smallest pK_a value of 4.77,** so it is the **strongest acid**.	 1 1
B8g	$2C_4H_9OH + 2Na \rightarrow 2C_4H_9O^-Na^+ + H_2$	1
B8hi	acidified potassium manganate(VII) / acidified potassium dichromate(VI)	1
B8hii	Acidified potassium manganate(VII) turns from **purple to colourless** / Acidified potassium dichromate(VI) turns from orange to green.	1
	TOTAL	**12**
B9a	Base. Methylamine accepts a proton / gains a hydrogen ion.	1
B9bi	Any pH above 7 and lower than 13	1
B9bii	Methylamine is a **weak alkali**. Hence methylamine dissolves and **dissociates partially in water to form a low concentration of hydroxide ions**, resulting in a lower pH than sodium hydroxide.	1 1

Qn	Suggested answers	Mark
B9ci	Titration	1
B9cii	• **Heat** the solution to **saturation.** • **Leave to cool** and for **crystals to form**. • **Filter the mixture** to obtain the crystals. • **Wash** the crystals with a little cold distilled water and then **dry** between sheets of filter paper. [every 2 points – 1m]	2
B9ciii	$(CH_3NH_3)_2SO_4$	1
	TOTAL	**8**
Either B10a	The particles are **far apart and disorderly / irregularly arranged**, and **moving randomly at high speeds.**	1 1
B10b	Fluorine / F_2. F_2 gains hydrogen atoms to form HF. Since F_2 is reduced, it is the oxidising agent. / The oxidation state of fluorine decreases from 0 in F_2 to -1 in HF. Since F_2 is reduced, it is the oxidising agent.	1 1
B10ci	The **energy absorbed to break bonds in Cl_2 is more than that for F_2**, as the bond energy of *Cl*-*Cl* is higher than that of the F-F bond.	1 1
B10cii	Energy released in Reaction 1 = 679 + 185 = 864 kJ Energy released in Reaction 2 = 595 + 543 = 1138 kJ	1 1
B10ciii	hydrogen fluoride / HF	1
B10civ	Dotted line to be drawn below the product (HF)	1
	TOTAL	**10**
Or B10a	aluminium chloride, phosphorus trichloride and phosphorus trifluoride They have low melting points.	1 1
B10bi	 [1m] – cation, [1m] – anion	2
B10bii	Molten and aqueous states Aluminium fluoride contains **mobile ions** which can act as charge carriers.	1 1
B10biii	Higher melting point. Aluminium oxide contains **oxide ions which have a higher charge** of 2- **compared to fluoride ions** with a charge of 1-. Hence, there are **stronger electrostatic forces of attraction / ionic bonds between the ions in aluminium oxide** so **more energy** is required to overcome the stronger ionic bonds.	 1 1
B10c	Phosphorus trichloride has a **higher melting point** than phosphorus trifluroide. Both have **simple molecular structures**, however **phosphorus trichloride has a higher relative molecular mass / is a larger molecule.** Hence, **more energy** is required to overcome the **stronger intermolecular forces of attraction in phosphorus trichloride.**	 1 1
	TOTAL	**10**