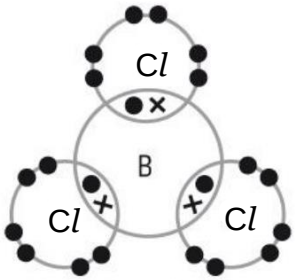
St. Joseph's Institution
2023 Year 4 OP Preliminary Exam Answer Scheme

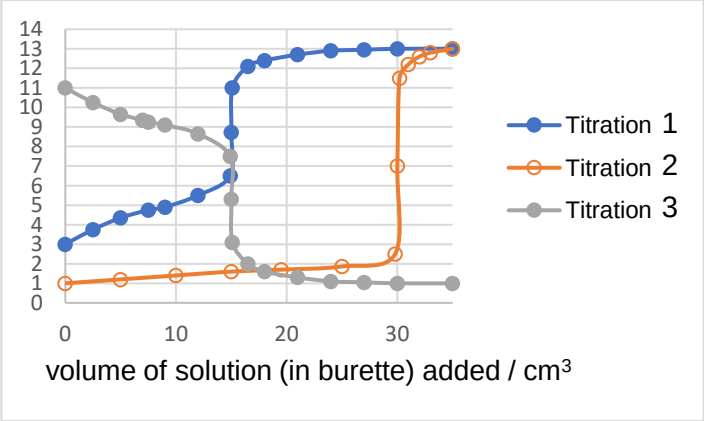
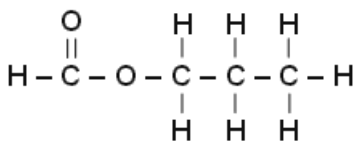
Paper 1

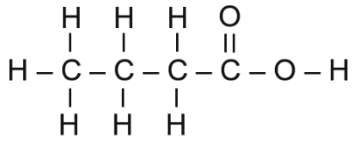
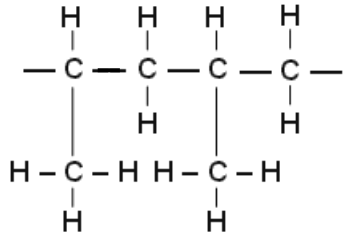
1	2	3	4	5	6	7	8	9	10
D	D	A	D	B	A	D	B	A	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	D	C	C	B	C	D	B	B	D
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
C	C	D	A	D	C	C	C	D	C
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
C	B	D	D	B	D	C	A	A	C

Paper 2 Section A

Qn	Suggested answers	Mark
A1a	sodium iodide	1
A1b	silver nitrate and sodium iodide	1
A1c	aluminium sulfate and zinc nitrate	1
A1d	ammonium chloride, silver nitrate and zinc nitrate	1
	TOTAL	**4**
A2a	There is **more oxygen** (from air) mixed with petrol, hence there is **less incomplete combustion** of petrol, thus producing lower amounts of carbon monoxide.	1
A2bi	Lightning activity	1
A2bii	Lean burn engine has a **lower operating temperature.** **Less nitrogen gas and oxygen gas will react** to form nitrogen oxides, as **this reaction only occurs at high temperatures.**	1 1
	TOTAL	**4**
A3a	There is no trend in the melting point, as it decreases from 2306 °C in boron to 30 °C in gallium then increases to 304 °C in thallium.	1
A3b	Aluminium has a **higher electrical conductivity** than sodium as it has **more mobile electrons** than sodium.	1
A3ci	 [1m] – bonding electrons [1m] – non-bonding electrons	2
A3cii	Boron has a **giant molecular/covalent structure**, while boron trichloride has a **simple molecular/covalent structure.** **A lot of energy** is needed to overcome the extensive network of **strong covalent bonds between the atoms** in boron. **Little energy** is needed to overcome the **weak intermolecular forces of attraction** between the molecules **in boron trichloride**.	1 1 1
	TOTAL	**7**

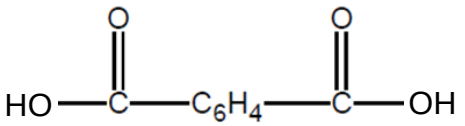
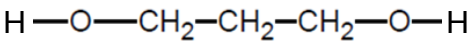
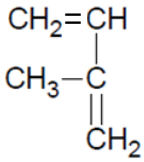
Qn	Suggested answers	Mark
A4a	$2H^+ + 2e^- \rightarrow H_2$ **Reduction** occurs at the silver electrode. The **hydrogen ions gain electrons** to form hydrogen gas.	1 1
A4b	Solution / electrolyte turns from **colourless to blue.**	1
A4ci	The **difference in reactivity** between lead and silver is **greater than** the difference in reactivity between copper and silver, thus resulting in a higher voltmeter reading.	1
A4cii	The lead anode **oxidises / dissolves** to **form lead(II) ions,** which react with the sulfate ions in the electrolyte to form **insoluble lead(II) sulfate.** The **concentration of mobile ions** in the solution **decreases**, thus the electrical conductivity decreases over time.	1 1
	TOTAL	**6**
A5ai	sodium, magnesium, **X**, lead, silver	1
A5aii	aluminium / zinc / iron / tin	1
A5aiii	$2Al + 3CuO \rightarrow Al_2O_3 + 3Cu$ / $Zn + CuO \rightarrow ZnO + Cu$ / $Fe + CuO \rightarrow FeO + Cu$ / $Sn + CuO \rightarrow SnO + Cu$	1
A5aiv	Aluminium / zinc / iron / tin is **more reactive than copper and displaces copper** from copper(II) oxide.	1
A5bi	**Difference (any one of the below):** • Iron has a high density but potassium has a low density. • Iron is hard but potassium is soft. • Iron has high melting and boiling points but potassium has low melting and boiling points.	1
A5bii	Galvanising with zinc forms a **protective barrier** and **prevents oxygen and moisture / water vapour from coming into contact with iron** and causing iron to rust. **Zinc is more reactive than iron** and hence **loses electrons / oxidises more easily** than iron and hence **corrodes in place of iron**.	1 1
A5ci	calcium carbonate	1
A5cii	The number of moles of each carbonate / percentage by mass of carbon in each carbonate / relative formula mass of each carbonate / relative atomic mass of the metal in each carbonate is different. [**Note:** the lower the A_r of the metal in the carbonate, the more moles of metal carbonate present in 2.00 g, and the more moles of $CO_2(g)$ evolved at the end of heating (i.e. greater mass loss).]	1
	TOTAL	**9**

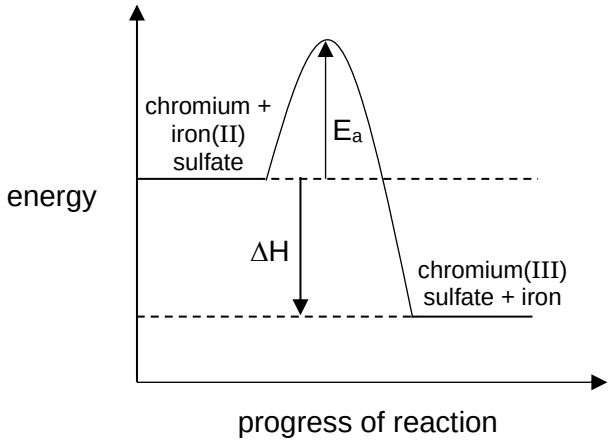
Qn	Suggested answers	Mark
A6ai	$H_2S(g) + CuSO_4(aq) \rightarrow CuS(s) + H_2SO_4(aq)$ [1m] – correct equation [1m] – state symbols	2
A6aii	• Place aqueous hydrogen sulfide into the **burette** • **Pipette** 25.0 cm^3 of aqueous potassium hydroxide into the conical flask • Add a few drops of **methyl orange indicator** • Perform **titration** to obtain the **average volume** of aqueous hydrogen sulfide required to react with 25.0 cm^3 of aqueous potassium hydroxide. • **Repeat the titration without the indicator**. • **Heat** the salt solution till **saturation**. • Allow the filtrate to **cool and crystals to form**. • **Filter the mixture** to obtain the crystals. • **Wash the crystals** with a little cold distilled water • **Dry the crystals** between sheets of filter papers. [1m] – choice of suitable indicator [1m] – titration to find average volume and repeating the titration without the indicator [1m] – crystallisation of potassium sulfide [1m] – washing and drying of potassium sulfide	4
A6bi	In titration 1, **ethanoic acid is a weak acid** that partially dissociates in water but in titration 2, **hydrochloric acid is a strong acid** which fully dissociates in water (to form H^+ ions). Thus, (initial) pH in titration 2 is lower than in titration 1. [For the same concentration of acid (0.1 mol/dm^3), HC*l* will have a higher concentration of H^+ ions than ethanoic acid.]	1
A6bii	(aqueous) sodium hydroxide / potassium hydroxide / any other strong Group I metal hydroxide	1
A6biii	Initial pH: between 7 and 12; **and** final pH: 1 or lower Steep drop in pH after **15 cm^3** of dilute H_2SO_4 added  	1 1
	TOTAL	**10**
A7a	naphtha fuel in cars lubricating oils	1 1 1
A7b	Cracking produces **shorter-chain / smaller hydrocarbons** which are in **greater demand** in the oil industry. Cracking forms **hydrogen** gas, which is used in the **Haber Process** / the large-scale **production of ammonia in industry.**	1 1
A7ci		1

Qn	Suggested answers	Mark
A7cii		1
A7ciii	$C_2H_6 + 2Br_2 \rightarrow C_2H_4Br_2 + 2HBr$	1
A7civ		1
A7cv	The polymer is **non-biodegradable** and may cause marine animals to chew on the polymer and choke / get trapped, suffocate and die.	1
	TOTAL	**10**

Paper 2 Section B

Qn	Suggested answers	Mark
B8ai	The reaction rate is **slower** at **B** than at **A**, as the **gradient** is **less steep at B** than at **A**.	1
B8aii	Yes. [must state but no mark] **All the nitric acid is used up** in the reaction, as its concentration became 0 mol/dm^3. Nitric acid is thus the limiting reagent, and Mg is added in excess.	 1
B8bi	A catalyst **provides an alternative pathway with a lower activation energy.** **More particles** would thus have **energies equal to or greater than the activation energy.** This **increases the frequency of effective collisions** between reacting particles, and thus the rate of reaction increases.	1 1
B8bii	Propanone / CH_3COCH_3 The oxidation state of iodine decreased from 0 in I_2 to -1 in HI (or -1 in CH_3COCH_2I). **Iodine has been reduced by propanone** so propanone is the reducing agent.	1 1
B8ci	Comparing **Experiments A and C**, where the concentration of I_2 and H^+ was kept constant, when the **concentration of propanone triples**, the **rate of reaction triples**. As the **rate of reaction is directly proportional to the concentration of propanone**, the reaction is first order with respect to propanone.	1 1
B8cii	Rate of reaction of Experiment **D** = 3.2 x 10^{-6} x 2 = 6.4 x 10^{-6} mol/(dm^3 s)	1
B8di	Rate of reaction of Experiment **E** = 3.2 x 10^{-6} mol/(dm^3 s) Experiments **A** and **E** have the **same rates of reaction**, as the **gradients** of their concentration-time graphs **are identical** (since both graphs were found to be parallel).	1 1
B8dii	zero order	1
	TOTAL	**12**

Qn	Suggested answers	Mark
B9a	***Monomers for PTT:***   ***Monomer for poly(isoprene):*** 	1 1 1
B9bi	No. of moles of repeating units in PTT = 1000 ÷ [11(12) + 10(1) + 4(16)] = 4.85437 mol = 4.85 mol (to 3 s.f.) No. of moles of repeating units in poly(isoprene) = 1000 ÷ [5(12) + 8(1)] = 14.7059 mol = 14.7 mol (to 3 s.f.)	1 1
B9bii	No. of moles of CO_2 formed from burning 1.0 kg of poly(isoprene) = 14.7059 x 5 = 73.5 mol (to 3 s.f.) No. of mol of CO_2 formed from burning 1.0 kg of PTT = 4.85437 x 11 = 53.4 mol (to 3 s.f.) [1m] for both calculations Burning 1.0 kg of poly(isoprene) **produces more carbon dioxide** than burning 1.0 kg of PTT. Carbon dioxide is a **greenhouse gas** which contributes to global warming.	1 1
B9biii	Number of repeating units in PTT = 4.85437 x 6 x 10^{23} = 2.91 x 10^{24} (to 3 s.f.)	1
	TOTAL	**8**
Either B10ai	Bond breaking reactions absorb energy and hence is endothermic. Bond forming reactions release energy and hence is exothermic. Since the **energy released in forming bonds** in the products (octane: carbon dioxide and water, hydrogen: water) is **greater than the energy absorbed in breaking bonds** in the reactants (octane / hydrogen and oxygen), both reactions are overall **exothermic** / have **net loss of energy to the surroundings** and hence the enthalpy change values are negative.	1 1
B10aii	Enthalpy change when 1 kg of octane is burnt = -5075 x $\frac{1000}{8(12)+18(1)}$ = -44500 kJ **OR** -4.45 x 10^4 kJ (to 3 s.f.) Enthalpy change when 1 kg of hydrogen is burnt = -286 x $\frac{1000}{2(1)}$ = -143000 kJ **OR** -1.43 x 10^5 kJ	1 1

Qn	Suggested answers	Mark
B10aiii	Octane is **easier to store** than hydrogen, as octane is a **liquid at room temperature**, whereas hydrogen is a **gas** at room temperature. Thus, hydrogen occupies a much **larger volume** than the same mass of octane. However, hydrogen **releases more energy** (i.e. has higher energy content) than octane when the **same mass of octane** (i.e. 1 kg) **is burnt.**	1 1
B10aiv	Hydrogen is produced by the **cracking** of long-chain hydrocarbons (an energy-intensive process), which requires the **burning of fossil fuels**. Burning fossil fuels **releases air pollutants** into the environment.	1
B10bi	A rapidly-depleting ozone layer would increase our **exposure to ultraviolet rays** entering the Earth, which is harmful and can lead to (increased risk of) **skin cancer / cataracts / gene mutations.**	1
B10bii	The **bond energy of a C-C*l* bond** (327 kJ/mol) is **lower than** the **bond energy of a C-F bond** (485 kJ/mol). (OR: the **C-C*l* bond is weaker than the C-F bond**). Given the same amount of energy from sunlight, **more C-C*l* bonds will be broken than C-F bonds**. Thus, the ozone layer will contain more chlorine atoms than fluorine atoms.	1 1
	TOTAL	**10**
Or B10ai	test 1: **pale green, dark green** test 3: **pale pink, pale pink** [2 correct – 1m]	2
B10aii	 [1m] – correct shape, names of reactants & products [1m] – activation energy, E_a [1m] – enthalpy change, ΔH	3
B10bi	$2Cl^- \rightarrow Cl_2 + 2e^-$ At the anode, **chlorine gas** is produced and chlorine **bleaches** the litmus solution, causing it to turn colourless.	1 1
B10bii	**Hydrogen (H^+) ions are preferentially discharged** at the cathode (over sodium ions). The solution near the cathode would thus have a **higher concentration of hydroxide (OH^-) ions than hydrogen (H^+) ions,** causing the pH to increase / solution to become more alkaline.	1
B10biii	At the **anode**, electrolysing dilute sodium chloride will produce **oxygen gas** (and water), while electrolysing concentrated sodium chloride will produce **chlorine gas**. **Sodium hydroxide** is formed in the solution (as the resulting electrolyte) after electrolysing concentrated sodium chloride, but **no sodium hydroxide / concentrated sodium chloride** is formed after electrolysing dilute sodium chloride.	1 1
	TOTAL	**10**