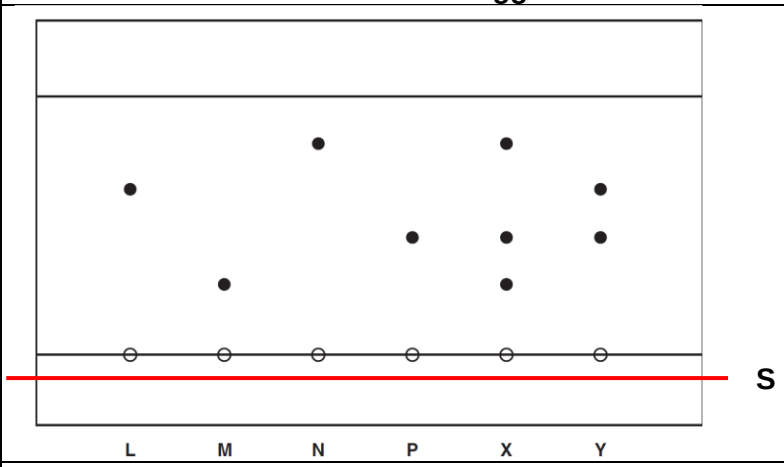
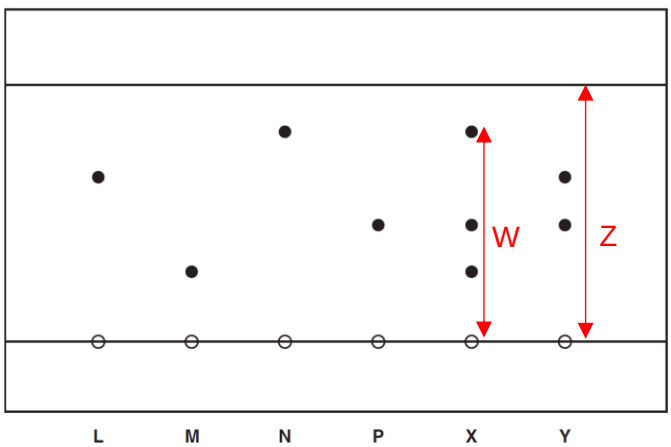
St. Joseph's Institution
2021 Year 4 OP Preliminary Exam Answer Scheme

Paper 1

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

Paper 2 Section A

Qn	Suggested answers	Mark
A1a		1
A1b	To react with the colourless spots to make them visible.	1
A1ci	X and Y	1
A1cii	L, M, N and P	1
A1d	 Show measurements on diagram (W and Z) R_f value = W / Z = (answer to 2 d.p)	 1 1
	TOTAL	**6**

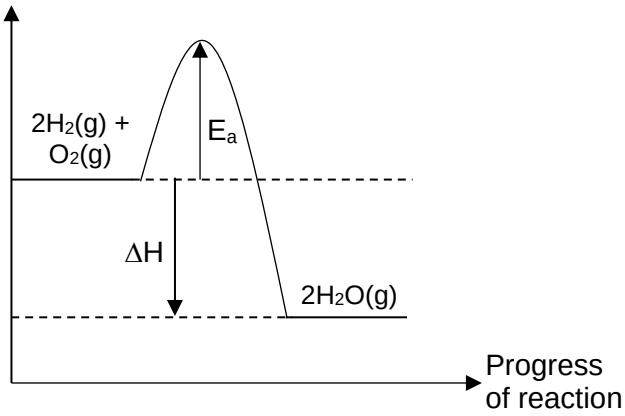
Qn	Suggested answers	Mark
A2ai	**400 – 450 °C, 200 – 250 atm**, finely divided **iron catalyst**	1
A2aii	Calcium hydroxide **reacts** with ammonium-based fertilisers to **form ammonia gas,** which **escapes** into the atmosphere. This results in the **loss of nitrogen** from the fertilizer which is **an important element for plant growth.**	1 1
A2bi	When aqueous ammonia is added dropwise then in excess, **green precipitate formed which is insoluble in excess** aqueous ammonia.	1
A2bii	$Fe^{2+}(aq) + 2OH^{-}(aq) \rightarrow Fe(OH)_2(s)$ [1m – ionic equation, 1m – state symbols]	2
A2ci	Ammonium chloride salt is **thermally unstable** and **<u>decomposes on heating</u>** to form hydrogen chloride and ammonia gas.	1
A2cii	crystallisation	1
A2d	calcium oxide / quicklime	1
	TOTAL	**9**
A3ai	An acid is a **substance or compound** that dissolves and **dissociates** in **water** to form **hydrogen ions** (as the only positive ions).	1
A3aii	$CH_3COOH(aq) \rightleftharpoons CH_3COO^{-}(aq) + H^{+}(aq)$ [1m – equation with reversible sign, 1m – state symbols]	2
A3b	Similarity: In both experiments, the **colourless solution turns blue** / **solid dissolves to form a blue solution.** Difference: In experiment 1, effervescence is observed which is not observed in experiment 2.	1 1
A3ci	$4KI + 2CuCl_2 \rightarrow 2CuI + I_2 + 4KCl$	1
A3cii	The oxidation number of copper decreases from +2 in $CuCl_2$ to +1 in CuI. This is reduction / $CuCl_2$ is reduced. The oxidation number of iodine increases from -1 in KI to 0 in I_2. This is oxidation / KI is oxidised. Since oxidation and reduction occurs simultaneously, this is a redox reaction.	1 1
A3d	step 1: Add **excess zinc oxide** to dilute hydrochloric acid. step 2: **Filter the mixture.** The filtrate is zinc chloride solution. step 3: Heat the **filtrate** to **saturation**, leave the solution to cool. Collect the crystals by filtration. step 4: **Rinse the crystals with distilled water** and **dry between pieces of filter paper.**	 1 1 1
	TOTAL	**12**

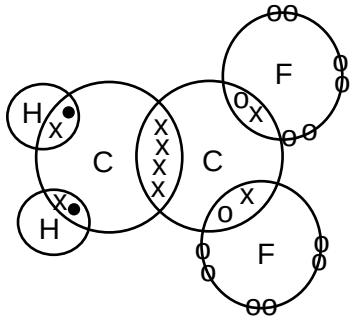
Qn	Suggested answers	Mark
A4a	Student A is wrong, Student B is correct. [must state but no mark] If concentration is decreased, the speed of reaction will decrease, however the **volume of carbon dioxide formed will also decrease** as **dilute hydrochloric acid is the limiting reactant** / zinc carbonate is in excess. If zinc carbonate granules are used, the **total surface area will decrease**, hence **speed of reaction will decrease**.	 1 1
A4bi	temperature	1
A4bii	When temperature decreases, the **reactant particles lose kinetic energy** and move slower. The **number of particles with energy equal or greater than the activation energy decreases.** There are lesser collisions, resulting in a **lower frequency of effective collisions** between reactant particles, hence, the **speed of reaction decreases**.	1 1
	TOTAL	**5**
A5a	Magnesium decreases in size / grey solid is formed around magnesium. Magnesium is a more reactive metal than zinc hence will displace zinc from zinc nitrate solution.	1 1
A5b	Iron solid decreases in size. Iron is more reactive than copper hence displaces copper from copper(II) sulfate solution. **OR** Colour of solution turns from blue to green. Iron displaces copper from blue copper(II) sulfate solution to form green iron(II) sulfate solution.	1 1
A5ci	Effervescence of colourless gas is observed on the iron rod. Magnesium loses electrons which flow to the iron attracting hydrogen ions which are selectively discharged as hydrogen gas.	1 1
A5cii	The aluminium has a **layer of oxide** coated on the surface hence it **cannot transfer electrons** to the iron / cannot **conduct electricity**	1 1
	TOTAL	**8**
A6ai	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e$	1
A6aii	Chloride ions are preferentially discharged because there is a **high concentration of chloride ions.**	1
A6aiii	12.5 cm^3	1
A6bi	sulfur dioxide	1
A6bii	Sulfur dioxide dissolves in moisture to form sulfurous acid. Sulfurous acid is further oxidized to form sulfuric acid which **dissolves in the rainwater as acid rain**. $SO_2 + H_2O \rightarrow H_2SO_3$ $2H_2SO_3 + O_2 \rightarrow 2H_2SO_4$	1 1

Qn	Suggested answers	Mark
	OR Sulfur dioxide reacts with moisture and oxygen in air to form sulfuric acid, which **dissolves in rainwater to form acid rain.** $2SO_2 + 2H_2O + O_2 \rightarrow 2H_2SO_4$	
A6biii	Flue gas desulfurization	1
A6ci	When hydrogen is burned, **only water** is produced which is not an air pollutant.	1
A6cii	When petrol is burned, it produces **carbon dioxide** which is a **greenhouse gas which traps excess heat,** **causing global warming**, leading to melting of ice caps at polar regions causing rise in sea level then flooding of lowland areas (or any other effects)	1 1
	TOTAL	**10**

Paper 2 Section B

Qn	Suggested answers	Mark
B7ai	The **more negative the E° value**, the **more reactive** the metal / The **more positive the E° value**, the **less reactive** the metal.	1
B7aii	copper, iron, nickel, zinc, magnesium, sodium	1
B7bi	+0.80 V [must state but no mark] Silver is **less reactive** than copper, hence the E° value must be more positive / larger.	 1
B7bii	$Ag^+(aq) + e \rightleftharpoons Ag(s)$	1
B7c	The salt bridge is used to **close the circuit** / maintain **electrical neutrality** / allow **ions to move from one electrolyte to another**	1
B7d	The decomposition of sodium carbonate produces **no products** but the decomposition of sodium nitrate produces **sodium nitrite and oxygen.** The decomposition of zinc carbonate and copper(II) carbonate produces the **metal oxide and carbon dioxide / one gas only** but the decomposition of zinc nitrate and copper(II) nitrate produces the **metal oxide, nitrogen dioxide and oxygen / two gases**.	1 1
B7e	Potassium nitrite and oxygen Since potassium is **more reactive** than sodium, and **sodium decomposes into sodium nitrite and oxygen**, then **potassium nitrate should also decompose similarly.**	1 1
B7fi	any value from 86 to 152 s	1
B7fii	Yes. [must state but no mark] The **more reactive the metal, the more thermally stable its compound**, hence the **longer the time taken to collect 50 cm^3 of gas.**	 1

Qn	Suggested answers	Mark
	Since nickel is more reactive than iron and less reactive than zinc, the time taken to collect 50 cm^3 of gas should be between 85 s to 153 s. / Since the time taken for copper(II) carbonate is 44 s and time taken for magnesium carbonate is 221 s, this shows that the time taken for the decomposition of carbonates of more reactive metals is longer.	1
	TOTAL	**12**
B8ai	The atomic radius of the Group I element is larger than that of the Group VII element.	1
B8aii	For the same period, there are **more protons** in an atom of a Group VII element than a Group I element hence the **electrostatic forces of attraction between the protons and valence electrons are stronger,** the valence shell is attracted closer to the nucleus making the atomic radius smaller for Group VII element.	1 1
B8b	Reactivity **increases down Group I**. The **atomic radius increases from 152 to 244 pm** down Group I, hence the **valence electron is further away from the nucleus**, hence the **electrostatic forces of attraction becomes weaker** hence the **valence electron is more easily lost**.	1 2
B8c	The **melting point increases** down Group VII. As the **molecular size / relative molecular mass increases**, the **intermolecular forces of attraction becomes stronger**. Hence **more energy** is needed to overcome the intermolecular forces of attraction.	2
	TOTAL	**8**
Either B9a	No. of moles of hydrogen = 40.0 / 2 = 20 mol No. of moles of oxygen = 30.0 / 32 = 0.9375 mol 1.875 mol of hydrogen will react completely with 0.9375 mol of oxygen. Thus hydrogen is in excess as 20 mol is greater than 1.875 mol and **oxygen is the limiting reagent**. Mole ratio of O_2 : H_2O = 1 : 2 No. of moles of H_2O = 0.9375 x 2 = 1.875 mol Mass of water = 1.875 x 18 = 33.75 = 33.8 g	 1 1 1
B9b	Energy / kJ  [1m] – correct shape, labelled axes, reactants & product [1m] – activation energy, E_a [1m] – enthalpy change, ΔH	3

Qn	Suggested answers	Mark
B9c	No I disagree. [must state but no mark] Addition of a catalyst will only provide an **alternative pathway with lower activation energy** for the reaction and a catalyst will not affect the enthalpy change for the reaction. Enthalpy change is dependent on the **number of moles of the reactants and products** and the **types of bonds / bond energies** in the reactants and products involved in the reaction.	 1 1
B9di	The particles change from m**oving at high speeds in random directions** to **sliding over each other**.	1
B9dii	In experiment 2, the **water vapour condenses to form liquid water**. This process is exothermic and additional **energy is released** during condensation.	1
	TOTAL	**10**
Or B9a	Neon has a **fully-filled valence electron shell / octet configuration / 8 electrons in outer shell** hence neon does not need to lose or gain electrons. Fluorine atoms have **7 valence electrons, needs to share 1 electron with another fluorine atom** to form a fully-filled valence electron shell / octet configuration.	1 1
B9b	**Weak intermolecular forces of attraction** between molecules which require **little energy to overcome**.	1
B9ci	Graphite. It has good electrical conductivity.	1
B9cii	In graphite, **each carbon atom is bonded to three other carbon atoms**, leaving a **valence electron which is unbonded.** The unbonded **electron** can delocalise and **move to conduct electricity**.	1 1
B9di	 	2
B9dii	Structure: Carbon sample (graphite) has a **giant molecular structure** but difluoroethene has a **simple molecular structure** / Carbon sample (graphite) has an extensive network of atoms while difluoroethene exists as discrete molecules. Bonding: There are strong **covalent bonds** present **between atoms** in both structures / There are weak **intermolecular forces of attraction** between layers of atoms in carbon sample (graphite) and between difluoroethene molecules. / There are strong **covalent bonds** between the atoms in the carbon sample but weak **intermolecular forces of attraction** between difluoroethene molecules.	1 1
	TOTAL	**10**