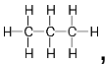
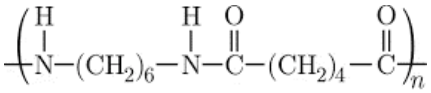
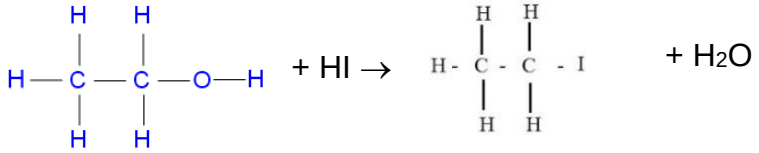
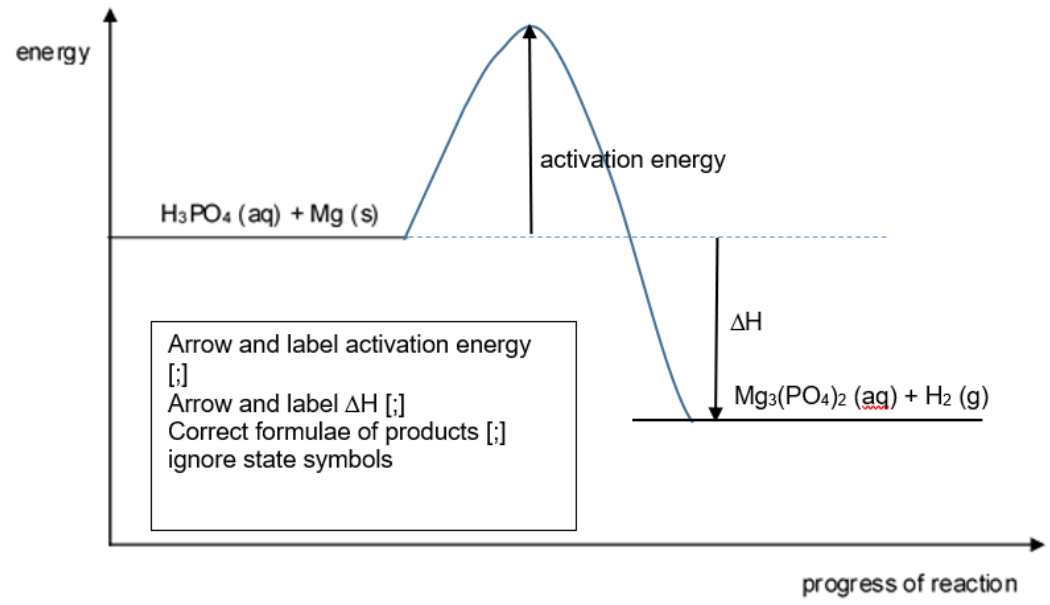
FUHUA SECONDARY SCHOOL
Sec 4E Chemistry 6092
Preliminary Examinations 2024 – Mark Scheme

PAPER 2
Section A [70 marks]

<table>
<tr><th>Q</th><th>Answer</th><th>Ma</th><th>Remarks</th></tr>
<tr><td>1a</td><td>Q and R</td><td>1</td><td></td></tr>
<tr><td>b</td><td>ZT_2</td><td>1</td><td></td></tr>
<tr><td>ci</td><td>shared electrons
non-bonded electrons</td><td>1
1</td><td></td></tr>
<tr><td>cii</td><td>Charge of Mg^{2+} and M^{3-} [;]
Three Mg^{2+} and two M^{3-} [;]
Outer electrons for Mg^{2+} and M^{3-}[;]</td><td>2</td><td>3; [2]</td></tr>
<tr><td>d</td><td><table><tr><th></th><th>true</th><th>false</th></tr><tr><td>Molecule 3 has lower boiling point then molecule 2.</td><td></td><td>✓</td></tr><tr><td>Molecule 3 is a saturated organic compound.</td><td>✓</td><td></td></tr><tr><td>Element Z reacts with oxygen to form acidic oxide only.</td><td></td><td>✓</td></tr><tr><td>Elements P and T are in Group 16.</td><td>✓</td><td></td></tr></table></td><td>2</td><td>4✓ [2]</td></tr>
<tr><td colspan="2">Total</td><td>8 marks</td><td></td></tr>
<tr><td>2ai</td><td>Mass of CO_2 = 100 – 97.8 = 2.2 g
Moles of CO_2 = 2.2 / 44 = 0.05 mol</td><td>1</td><td></td></tr>
<tr><td>ii</td><td><table><tr><th>experiment</th><th>particle size</th><th>volume of acid / cm^3</th><th>concentration of acid / mol/dm^3</th></tr><tr><td>1</td><td>powder</td><td>50
e.c.f from (a)(i) mole</td><td>2.0</td></tr><tr><td>2</td><td>lump</td><td>200 [1]
(must be 4x of expt 1/ 2x of expt 3)</td><td>1.0</td></tr><tr><td>3</td><td>Powder [;]
Same as expt 1</td><td>100 [;]
2x of expt 1</td><td>2.0 [;]
Same as expt 1</td></tr></table>Expt 1: mole of H^+ = 0.05 x 2 = 0.10 mol
Volume of acid = 0.10 / 2.0 = 0.05dm^3 = 50 cm^3</td><td>1
1
1</td><td>3; [1]</td></tr>
<tr><td>2b</td><td>As <u>particle size decreases[;]</u>, there is a <u>larger exposed surface area[;]</u> of barium carbonate in contact with the acid. There are more collisions and <u>increase in frequency of effective collisions between barium carbonate and H^+ ions the acid particles[;]</u>, hence <u>increasing speed of reaction[;]</u>.</td><td>2</td><td>4; [2]
2; [1]</td></tr>
<tr><td>c</td><td>Add aq. silver nitrate solution to each acid, if white ppt forms, the acid is HCl. OR
Add aq. NaOH, aluminium foil to each acid and heat the mixture, if ammonia gas is produced (moist red litmus turns blue), the acid is HNO_3.</td><td>1</td><td></td></tr>
</table>

d	Rate will be slower [;] and change in mass will be the same [;] as experiment 1. Ethanoic acid is a <u>weak acid which dissociates partially in aqueous solution to give a lower concentration of H^+ ions [;]</u> compared to the strong acid, hence rate is slower. The <u>acid / H^+ ions remains as the limiting reagent / same number of moles of H^+ ions used [;]</u> hence mass of gas produced is the same and same change in mass of the reaction.	3	4[;] – [3], 2-3[;] – [2], 1[;] – [1]
	Total		10 marks
3ai	Concentration of $CuSO_4$ decreases [;] from 1.10 mol/dm^3 until all Cu^{2+} ions in solution reduced to form Cu at the cathode. [;] $Cu^{2+}(aq) + 2e \rightarrow Cu(s)$ [;]	2	3; [2]
ii	Amount of Cu deposited = 200/1000 X (1.10 – 0.22) = 0.176 mol Mass of Cu = 0.176 X 64 =11.3 g	1 1	
bi	straight horizontal line at 1.10 g	1	
ii	Colourless gas given off at the graphite electrode. Grey / silvery solid deposited on the iron object.	1 1	
c	Once tin is scratched, <u>iron will lose electrons / oxidise more readily</u> to form iron(II) ions as <u>tin is less reactive than iron</u>	1 1	
	Total		9 marks
4a	butyl propanoate[;], butanol[;], propanoic acid[;]  , addition of hydrogen Accept catalytic hydrogenation.  , addition polymerisation Reject 'additional polymerisation'  , condensation polymerisation	2 1 1 1	3 ; [2], 1; [1]
bi	Any two of the following: • Members have the same general formula $C_nH_{2n+1}X$ • There is gradual increase in boiling point as the number of carbon atoms increases. • Successive members differ from the next by a $–CH_2$ group.	2	
ii	As the halogen atom changes from C*l* to I, the boiling point of the alkyl halide increases. The size of halogen atom increases from C*l* to I, <u>molecular mass / molecular size of alky halide increases</u> [1] and hence boiling point increases. <u>Intermoleular forces of attraction between molecules increases</u> and <u>amount of energy taken in to overcome these forces increasesi</u>	1 1 1	
iii			

	 + H_2O displayed formulae of organic compounds balanced equation and formulae of other chemicals	1 1	
	Total	12 marks	
5a	When chromium is heated with manganese oxide, there is no visible change. [;] as chromium is less reactive than manganese. [;] When chromium is heated with copper (II) oxide, black CuO turned to reddish-brown Cu / grey Cu turned to green Cr_2O_3./ black CuO and grey Cr turned to green Cr_2O_3.and reddish-brown Cu. Chromium is more reactive than copper and displaces copper from CuO.	1 1 1	2; [1]
b	$3Mn (s) + 2Cr^{3+} (aq) \rightarrow 3Mn^{2+} (aq) + 2Cr (s)$	1	
c	Blue solution turned green and grey metal coated with a reddish-brown solid.	1	
	Total	5 marks	
6a	<table><tr><th></th><th>colour and state at room temperature and pressure</th></tr><tr><td>chlorine</td><td>Greenish-yellow gas [;]</td></tr><tr><td>bromine</td><td>Reddish-brown liquid [;]</td></tr><tr><td>iodine</td><td>Purplish-black solid [;]</td></tr></table>	2	2; [1] 3; [2]
b	In the first experiment, bromine is more reactive than iodine [;] and displaces iodine from aqueous iodide[;] , forming aqueous iodine which is brown. [;] In the second experiment, iodine is less reactive than chlorine [;] and unable to displace chlorine from aqueous chloride ions. Hence aqueous iodine remains and is brown solution. [;]	2	4; [2] 2; [1]
c	The oxidation state of chlorine increases from 0 in Cl_2 to +1 in OCl^- and decreases to -1 in Cl^-. Therefore, chlorine is oxidised and reduced simultaneously.	1 1	
	Total	6 marks	

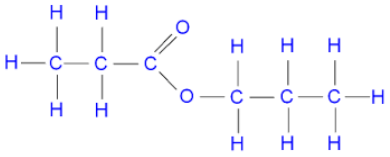
7a	Measure each sample of acid with a pH meter AND If the pH reading ranges from 3 to 6, then it is a weak acid OR Add a few drops of Universal indicator to each sample AND If the indicator changes to a yellow or orange colour, it is a weak acid [1]	1	
b	volume ratio 3: 2	1	
c	1. Add **aqueous sodium tartarate** to a fixed volume of **aqueous copper(II) nitrate** in a beaker till no more precipitate is formed. [1] 2. Filter the mixture to obtain copper(II) tartarate as a residue 3. Wash the residue with a little distilled water and pat dry between pieces of filter paper.	1 ; ;	2; [1]
di	6.0°C [;] Since the magnesium ribbon is the limiting reactant [;], amount of heat energy given out is the same for same no. of moles of Mg [;]	2	3; [2] 1-2; [1]
ii		2	3; [2] 1-2;[1]
	Total	8 marks	

8ai	HCFC-123	2	
ii	CFC-114: $C_2Cl_2F_4$ HFC-125: C_2HF_5	1 1	
b	Comparing CFC-11 and HCFC-22 and HFC-23 with one carbon atom in each molecule, [;]		9; [4] 7-8; [3] 4-6; [2] 1-3; [1]

	HCFC	HFC	CFC
ODP	HCFC-22 has ODP of 0.04 less than CFC-11 but more than CFC-11. [;]	HFC-23 has the lowest ODP at less than 4×10^{-4}. [;]	CFC-11 has the highest ODP of 1.00. [;]

	GWP	HCFC-22 has the least GWP of 1700 [;]	HFC-23 has the highest GWP at 12100. [;]	CFC-11 has GWP of 4000 [;]		
	Although use of HFC reduces the ozone layer depletion the least, reduces ODP by 2500X but it increases global warming to the greatest extent, increases GWP by 3X. [;] Use of HCFC reduces ODP by 25X reduces GWP by 2.4X.[;]					
ci	CFC molecule releases one C*l* atom in presence of sunlight.[;] Chlorine atom consumed by reacting with one O_3 molecule [;] is regenerated when C*l*O reacts with another O_3 molecule in the second step. [;] Hence overall Cl atoms is not used up / no net loss of chlorine atoms.[;]				2	4; [2] 1-3; [1]
ii	Agree C-F and C-H have higher bond energy values (485 and 413 kJ/mol) than C-C*l* (328 kJ/mol) , less (light) energy is taken to break the C-C*l* bonds to release C*l* atoms which react with ozone.				1 1	
d	Ammonia and carbon dioxide do not react with ozone.				1	
	Total				12 marks	

Section B [10 marks]

Q	Answer	M	Remarks
9ai	$C_5H_{12} \rightarrow C_2H_6 + C_3H_6$	1	
ii	Add aqueous bromine to **A** and **B** separately. [;] For **A**, aqueous bromine remained reddish-brown. [;] For **B**, reddish-brown aqueous bromine turned colourless.[;]	2	3; [2] .
iii	Displayed formula for propyl propanoate 	1	
bi	Mr of repeat unit = 114 When M_r = 16 000, number of repeating units = 16 000/114 = 140.35 [;] = 141 [**round up**] When Mr = 50 000, number of repeating units = 50 000/114 = 438.596 = 438 [**round down**] [;] Therefore, the range of the average number of repeating units is between 141 and 438 [1] inclusive.	1 1	2; [1]
ii	displayed formula $HOOCCH_2CH_2COOH$ $HOCH(CH_3)CH_2OH$	1 1	

iii	M_r of dicarboxylic acid ($C_4H_6O_4$) = 118 M_r of diol ($C_3H_8O_2$) = 76 No of moles of dicarboxlic acid = 1000/118 = 8.47458 Dicarboxyic acid is limiting. No of moles of polymer = 8.47458 Mass of polymer produced = 8.47458 × (118+76-2×18) = 1338 g = 1.34 kg OR consider terminating monomer for each molecule Mass of polymer produced = 8.47458 × (118+76)- (8.47458-1)(18) = 1509.5 g = 1.51 kg	1 1	
	Total	10 marks	
10ai	As the air/fuel ratio changes from rich to lean, the conversion efficiency of CO and HC increases but that of NOx decreases. As the air/fuel ratio changes from rich to lean, the amount of oxygen available to oxidise CO to CO_2 increases, amount of oxygen available to oxidise HC to CO_2 increases. lesser CO amount available to reduce NO and hence conversion of NO_x decreases.	1 1 1 1	
ii	Nitrogen oxide causes respiratory problems. Inhalation of carbon monoxide prevents haemoglobin from absorbing oxygen and may lead to suffocation / organ failure / headaches. [NB: discuss effect of each gas separately]	1 1	
bi	Step 1: Aqueous barium chloride removes the sulfate ions by precipitation due to formation of $BaSO_4$ which is insoluble. Step 2: Aqueous sodium carbonate removes the calcium, magnesium and iron(III) ions and the excess barium ions by precipitation due to the formation of $CaCO_3$, $MgCO_3$ & $Fe_2(CO_3)_3$ which are insoluble.	1 1	
ii	Substance **Z** is hydrochloric acid. Hydrochloric acid reacts with carbonate ions to form water and carbon dioxide gas.	1 1	
	Total	10 marks	