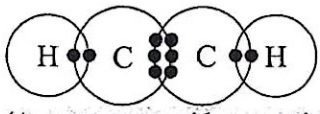
Part I

Marks

1. (a) 

1
(Accept answer with correct inner shell electrons)
(Not accept answer with incorrect inner shell electrons, if inner shell electrons are drawn)

(b) $2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l)$ 1
(State symbols not required)(Ignore incorrect state symbols)

(c) (i) hydrogen / H_2 1

(ii) Hydrogen is explosive / flammable. 1

(d) $Ca(OH)_2$ can be used in treating acidic soil / use in scrubber / treating acidic flue gas / treating acidic sewage / treating sewage by precipitation / making preserved eggs / making cement or concrete / etc. 1

2. (a) (Reddish) brown (fume / liquid) 1
(Accept: orange; Not accept: yellow or red; Not accept: solid)

(b) $Pb^{2+}(l) + 2e^- \rightarrow Pb(s)$ 1
(State symbols not required)(Ignore incorrect state symbols)

(c) $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$ 1
(State symbols not required)(Ignore incorrect state symbols)
(For (b) and (c), not accept "$\rightleftharpoons$", "$\longrightarrow$", and "e")
(For (b) and (c), deduct 1 mark if any one of "$\rightleftharpoons$", "$\longrightarrow$", and "e" is used in both parts, and all others are correct)

(d) hydrogen / H_2 1

(e) $Cu^{2+}(aq)$ / copper(II) ion 1

(f) Brown solid formed. / The electrode increased in size. / The electrode increased in mass. 1

(g) Cu^{2+} is lower than H^+ in electrochemical series. / 1
Cu^{2+} is a stronger oxidising agent than H^+./
Cu^{2+} accepts electrons more readily than H^+.
(Accept: state electrochemical series as E.C.S.)
(Not accept: symbols without charges, like: Cu is lower than H in electrochemical series)
(Not accept: Cu^{2+} is a better oxidising agent than H^+)

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Marks

3. (a) Atoms with the same number of protons but different numbers of neutrons / 1
Atoms with the same atomic number but different mass numbers
(Accept: Atoms of the same element but with different numbers of neutrons / different mass numbers)

(b) $x + y = 100 - 92.2 = 7.8$ therefore $y = 7.8 - x$
$(92.2 \times 28 + x \times 29 + (7.8 - x) \times 30) / 100 = 28.1$ 1*
$x = 5.6$ 1
(Deduct 1 mark if the candidate can perform the calculation correctly but there are mistakes in the presentation / treatment of "%")

(c) (i) SiO_2 has a giant covalent structure / giant covalent network. 1
The (Si and O) atoms are linked by strong covalent bond. / 1
Si / Silicon and O / oxygen are linked by strong covalent bond. (Not accept: Si / O ions)

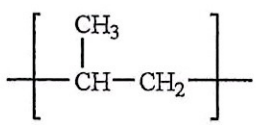
(ii) No. of moles of Mg = 1.0 / 24.3 = 0.0412
No. of moles of SiO_2 = 1.0 / 60.1 = 0.0166
Mole ratio of SiO_2 to Mg is 1 : 2
The no. of moles of Mg required to react completely with 1.0 g SiO_2 is 0.0332. Therefore, 1*
Mg is in excess and 0.0166 mol of Si can be formed.
(1 mark for correct deduction of Mg is in excess / SiO_2 is limiting. Showing the mole ratio SiO_2:Mg is 1:2 is required)
The mass of Si can be formed = 28.1 x 0.0166 = 0.466 g 1
(Correct unit is required) (Accept 0.466 – 0.48) (max. 4 significant figures)

(d) Quartz 1
(Accept: silicon dioxide / SiO_2 / silica / silicate) (Not accept: sand)

4. (a) † propene 1
(Not accept: propylene)

(b) **X** can turn Br_2 (in organic solvent) solution from orange/brown to colourless but butane cannot. 1 + 1
/ **X** can turn MnO_4^-(aq)/H^+(aq) from purple to colourless but butane cannot.
(1 mark for correct reagent, 1 mark for correct observation with comparison)
(Br_2 : Accept bromine water; reddish–brown; Not accept: yellow/red)
(MnO_4^-: Accept MnO_4^- or MnO_4^-/OH^-; purple (solution) to brown precipitate)
(Accept: Combustion test (1);
X gives more sooty flame, while butane gives less sooty flame (1))

(c) (i) **X** has a C=C double bond / carbon-carbon double bond. 1
(Not accept: **X** is an alkene)

(ii)  1

(d) (i) $HC(CH_3)_3$ 1

(ii) • Decane 1
• The molecular size of decane is the biggest among them so that the van der Waals' forces between decane molecules are the strongest. / 1
If the size of a molecule is larger, the van der Waals' forces between the molecules are stronger.
(Accept: more electrons / larger surface area) (Not accept: higher molecular mass)

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Marks

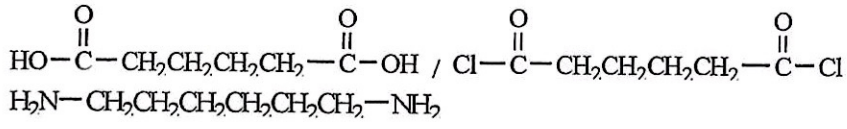
5. (a) Covalent bonds in the reactants are broken and covalent bonds in the products are formed. 1
N–C, C–H, O=O bonds (at least 2) are broken; C=O, H–O, N–O / N=O bonds (at least 2) are formed. (Not accept: C–O bonds are formed.) (1)
Bonds in hexamine / oxygen are broken and bonds in CO_2 / H_2O / NO_2 are formed. (1)
The total energy released in the bond forming processes is larger than the total energy absorbed in the bond breaking processes. 1
The total energy used / absorbed in bond breaking is smaller than the total energy released / given out in bond forming. (1)

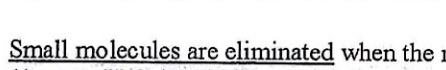
(b) (i) $6C(s) + 6H_2(g) + 2N_2(g) \rightarrow C_6H_{12}N_4(s)$ $\Delta H_f^\ominus = +123$ kJ mol^{-1} 1
(Correct state symbols) (Accept $\Delta H = +123$ kJ mol^{-1})

(ii) $\Delta H_c^\ominus = 6 \times (-394) + 6 \times (-286) + 4 \times (+33) - 123$ 1*
$= -4\,071$ kJ mol^{-1} (Correct sign and unit) 1

(c) Energy released = $\underline{600.0 \times 4.20 \times (47.5 - 23.5)}$ or $\underline{600.0 \times 4.20 \times 24.0}$ 1*
$= 60\,480$ J
$\Delta H_c = -60\,480 \div (2.40 \div 140.0)$ 1*
$= -3\,528$ kJ mol^{-1} or -3.528×10^3 kJ mol^{-1} or $-3\,528\,000$ J mol^{-1} 1
(Accept: –3528 / –3529 / –3530 / –3537 / –3540, with 3–4 significant figures only.)
(Correct sign and unit)

5. *For CS*:

(a)  1



1

(b) Small molecules are eliminated when the monomers are joining together to form polymer. 1
(Accept: H_2O / HCl is formed during the polymerisation.)

Provided by dse.life

Marks

6. (a) (i) Avoid the cracking of reaction tube due to the flowing back of (condensed) water formed. 1

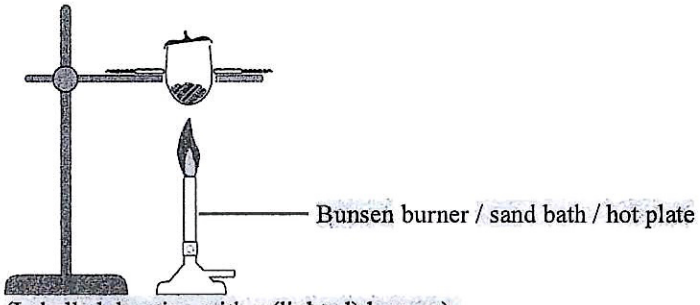
(ii) Ammonia is poisonous / flammable / corrosive / with a pungent smell / irritating / choking. 1
Lead(II) oxide is toxic / may cause cancer. (Not accept: "lead oxide") (1)
Lead is toxic / may cause cancer. (1)

(b) $3PbO(s) + 2NH_3(g) \rightarrow 3Pb(s) + N_2(g) + 3H_2O(l)$ 1
(State symbols not required)

(c) The reducing agent is ammonia / NH_3 as the oxidation number (O.N.) of N increases from –3 to 0. 1
(Accept: O.N. of N changes from –3 to 0 / O.N. of N –3 → 0)
The reducing agent is ammonia / NH_3 as oxidation number of Pb decreases from +2 to 0.
Lead(II) oxide / PbO is reduced as oxidation number of Pb decreases from +2 to 0, hence ammonia / NH_3 is the reducing agent.
(In terms of oxidation number)
Lead(II) oxide / PbO loses oxygen to ammonia / NH_3, hence ammonia / NH_3 is the reducing agent. (1)
Ammonia / NH_3 loses hydrogen to lead(II) oxide / PbO, hence ammonia / NH_3 is the reducing agent.
(In terms of gain or loss of hydrogen / oxygen)
Lead(II) oxide / lead(II) ions / PbO / Pb^{2+} gain electrons from ammonia / NH_3, hence ammonia / NH_3 is the reducing agent. (1)
Ammonia / NH_3 loses electrons to lead(II) oxide/ lead(II) ions / PbO / Pb^{2+}, hence ammonia / NH_3 is the reducing agent.
(In terms of gain or loss of electrons)

(d) (i) $2PbO(s) + C(s) \rightarrow 2Pb(s) + CO_2(g)$ 1
$PbO(s) + C(s) \rightarrow Pb(s) + CO(g)$ (1)
(State symbols not required)

(ii) (1)



1
(Labelled drawing with a (lighted) burner.)
(Accept: Bunsen burner with wire gauze and tripod)

(2) crucible † 1

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Marks

7. (a) Steps: 1+1
(1) Dissolve the anhydrous sodium carbonate solid in a sufficient amount (less than 250 cm^3) of deionised / distilled water in a clean beaker.
(2) Transfer the solution into a 250 cm^3 volumetric flask (with a filter funnel).
(3) Rinse the beaker / filter funnel with deionised / distilled water several times and transfer all the washings into the volumetric flask.
(4) Make up to the graduation mark with deionised / distilled water.

(Correct steps (2) and (4): 1 mark, correct step (3): 1 mark.)

Dissolve the anhydrous sodium carbonate solid directly in a 250 cm^3 volumetric flask. (1)
Make up to the graduation mark with deionised / distilled water.

(b) From yellow to orange / yellowish orange / orange red 1
(Not accept: "red")

(c) After discarding the third set of data, the reasonable average volume of HCl(aq) used
$= (27.25 + 27.30 + 27.25) \div 3$
$= 27.27\ cm^3$ (Correct unit) 1

(d) $Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$
$\therefore$ Mole ratio of $Na_2CO_3(aq)$ to $HCl(aq) = 1 : 2$
Number of moles of HCl $= 0.1038 \times 25.0 \times 10^{-3} \times 2 = 0.00519$ 1*
/ Number of mole of HCl $= (2.750 \div 106.0) \times 2 = 0.005189$ (1*)
Concentration of HCl(aq) in g $dm^{-3} = 0.00519 \div (27.27 \times 10^{-3}) \times 36.5$ 1*
$= 6.947$ (No unit / correct unit) 1
(Accept: 6.93 – 6.95, and with 3-4 significant figures only)

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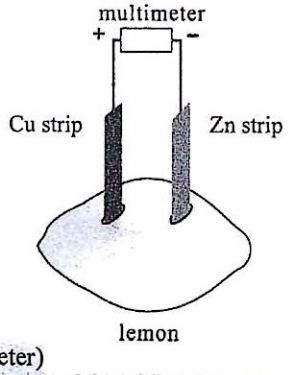
Marks

8. Chemical knowledge



1

(Accept Ⓥ instead of a multimeter)
(Show a proper functioning cell with two labels – 'metal strips', 'Zn strip' and 'Cu strip', etc.. No need to show the positive and negative terminals of the multimeter.)

- [Experiment 1] Construct a Zn-Cu cell by connecting the Zn strip and the Cu strip to the negative terminal and the positive terminal of a multimeter respectively, a positive voltage / reading can be recorded. 1
  The result of this experiment indicates that Zn has a higher tendency to release electrons[#1] than Cu, thus Zn has a higher reducing power than that of Cu[#2]. 1
- [Experiment 2] Repeat the experiment by replacing the Zn strip with the Ag strip, a negative voltage / reading can be recorded. 1
  The result of this experiment indicates that Cu has a higher tendency to release electrons[#1] than Ag, thus Cu has a higher reducing power than that of Ag[#2]. 1
  (Note: #1 Describe "Zn has a higher tendency to release electrons than Cu, etc." at least once, #2 Make use of the deductions from both Expt 1 AND Expt 2 to confirm the order Zn > Cu > Ag.)

or

- [Experiment 2] Construct a Zn-Ag cell by connecting the Zn strip and the Ag strip to the negative terminal and the positive terminal of a multimeter respectively, a (greater) positive voltage / reading can be recorded. (1)
  The result of this experiment indicates that Zn has a higher tendency to release electrons[#1] than Ag, thus Zn has a higher reducing power than that of Ag, and the greater voltage / reading of this cell when compared to the Zn-Cu cell in experiment 1 suggests that Ag has the lowest reducing power[#2]. (1)
  (Note: #1 Describe "Zn has a higher tendency to release electrons than Cu, etc." at least once, #2 Compare the magnitures of voltage reading from both Expt 1 AND Expt 2 to confirm the order Zn > Cu > Ag.)
- Therefore, the order of reducing power of metals can be confirmed as Zn > Cu > Ag.

- Communication mark 1
  (Chemical knowledge = 0 to 3, communication mark = 0.
  Chemical knowledge = 4 to 5, communication mark = 0 or 1.
  Incomplete answer or difficult to understand, communication mark = 0.)

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Part II

Marks

9. (a) $\dfrac{[H_2(g)]^4[CS_2(g)]}{[CH_4(g)][H_2S(g)]^2}$ 1

(b) (i) 0.055 1

(ii) $K_c = \dfrac{[\frac{0.02}{2}]^4[\frac{0.025}{2}]}{[\frac{0.055}{2}][\frac{0.11}{2}]^2}$ 1*

$= 1.50 \times 10^{-6}$ mol^2 dm^{-6} (Correct unit is required) 1

(Accept: 1.5×10^{-6} / 1.503×10^{-6} / 1.5026×10^{-6} – max. 5 significant figures)

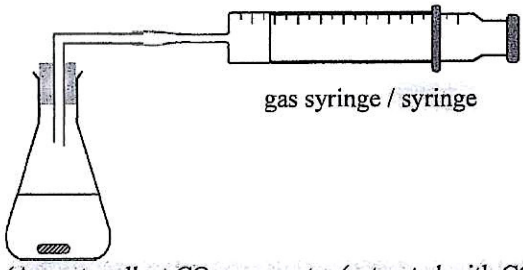
(Not accept: M^2 or (mol dm^{-3})^2)

(iii) K_c remains unchanged as it only depends on temperature / is independent of concentration of reactants and products. 1

(Accept: independent of pressure)

10. (a) (i) $CO_2(g)$ is soluble in water. / To make sure no CO_2 can dissolve in the solution. 1

(ii) 1



(Accept: collect CO_2 over water (saturated with CO_2), and label the measuring cylinder or having scales drawn on the drawing)

(b) (i) No. of moles of $CO_2(g)$ = 0.0500 / 24.0 = 0.00208 1*

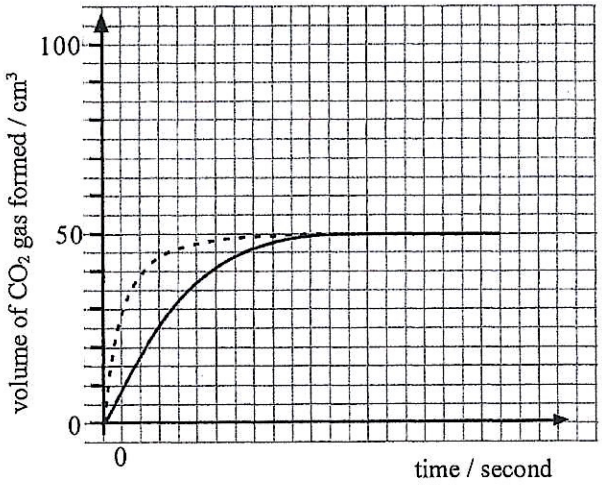
1 mole of $NaHCO_3(s)$ would give 1 mole of $CO_2(g)$

No. of moles of $NaHCO_3(s)$ = 0.00208

Mass of $NaHCO_3(s)$ = 0.00208 × 84 = 0.175 g (Correct unit is required) 1

(Accept: 0.1747 – 0.1764; max. 4 decimal places)

(ii) 1



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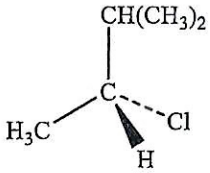
Marks

11. (a) In the addition reaction / of hydrogen halide (HX) to the C=C double bond of / an alkene, the hydrogen atom in HX is added to the carbon atom with the greater number of hydrogen atoms / while the halogen atom in HX is added to the carbon atom with the smaller number of hydrogen atoms. 1

(b) $(CH_3)_2CClCH_2CH_3$ 1

(c) NaOH(aq) / KOH(aq) / OH^-(aq) (State symbols not required) 1

(d) (i) 

(or its enantiomer) 1

(ii) It can rotate the plane of plane polarised light. 1

(e) Use $Cr_2O_7^{2-}$(aq) / H^+(aq) 1
Z turns $Cr_2O_7^{2-}$(aq) / H^+(aq) from orange to green while no observable change for 2-methylbutan-2-ol. 1

Other possible test and corresponding observations:		
	Z	2-methylbutan-2-ol
MnO_4^- / H^+	change from purple to colourless	no observable change
MnO_4^-	form brown ppt. from purple (solution)	no observable change
MnO_4^- / OH^-	form brown ppt from purple (solution)	no observable change
Anhyd. $ZnCl_2$/conc HCl	form oily layer slowly	form oily layer instantly
I_2 / NaOH	form yellow ppt.	no observable change

(Accept: state the chemical tests as Lucas' test / Iodoform test)

12. (a) (i) Silicon dioxide can neutralise / react with alkalis / bases to form salt and water only. 1

(ii) Silicon dioxide is insoluble in water. / 1
Silicon dioxide does not react with water.

(b) Phosphorus(V) oxide reacts with /dissolves in water to form phosphoric acid / that can give H^+. 1
$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$ / $P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$ 1
(State symbols not required) (Ignore incorrect state symbols)
(Accept: $P_2O_5(s) + 3H_2O(l) \rightarrow 6H^+(aq) + 2PO_4^{3-}(aq)$)

(c) • Copper has variable oxidation states: +1 in Cu_2O, +2 in $CuSO_4$ 1
• Copper has coloured ions: Cu^{2+}(aq) / $CuSO_4$(aq) is blue. 1

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Marks

13. • Monomer: $HOOC(CH_2)_4COOH$ and $H_2N(CH_2)_6NH_2$ 1
(Accept: $ClOC(CH_2)_4COCl$)
(Accept: correct structures or names of the monomers: hexanedioic acid / hexane-1,6-diamine / hexanedioyl chloride)

• Monomers should be bifunctional. 1

• The functional groups at the two ends of the monomers react repeatedly forming the amide bonds. 1
(Accept answer expressed as chemical equation)

• Small molecules are eliminated, such as H_2O. (Accept: HCl, need to match with the corresponding monomer) 1

• Communication mark 1
(Chemical knowledge = 0 to 2, communication mark = 0.
Chemical knowledge = 3 to 4, communication mark = 0 or 1.
Incomplete answer or difficult to understand, communication mark = 0.)

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2021年香港中學文憑
HONG KONG DIPLOMA OF SECONDARY EDUCATION 2021

CHEMISTRY PAPER 2

MARKING SCHEME

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INSTRUCTIONS TO MARKERS

1. In order to maintain a uniform standard in marking, markers should adhere to the marking scheme agreed at the markers' meeting.

2. The marking scheme may not exhaust all possible answers for each question. Markers should exercise their professional discretion and judgment in accepting alternative answers that are not in the marking scheme but are correct and well reasoned.

3. The following symbols are used:

/	A single slash indicates an acceptable alternative within an answer.
*	Step-mark (for questions involving calculations)
†	Correct spelling required

4. In questions asking for a specified number of reasons or examples etc. and a candidate gives more than the required number, the extra answers should not be marked. For instance, in a question asking candidates to provide two examples, and if a candidate gives three answers, only the first two should be marked.

5. In cases where a candidate answers more questions than required, the answers to all questions should be marked. However, the excess answer(s) receiving the lowest score(s) will be disregarded in the calculation of the final mark.

6. Award zero marks for answers which are contradictory.

7. Chemical equations should be balanced except those in reaction schemes for organic synthesis. For energetics, the chemical equations given should include the correct state symbols of the chemical species involved.

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Equations must be balanced. States are optional. Give mark even the states are not correct.

Marks

1. (a) (i) +49.2 kJ mol^{-1} (Accept: 49.2 kJ mol^{-1}; Not accept: –49.2 or in J mol^{-1}) 1

(ii) $\log \frac{k}{k_1} = \frac{-E_a}{2.3R}\left(\frac{1}{310} - \frac{1}{300}\right)$ 1

$\log \frac{k}{k_1} = \frac{-65\times10^3}{2.3\times8.31}\left(\frac{1}{310} - \frac{1}{300}\right)$ (1)

$k = 2.32\ k_1$ 1

(Accept: 2.30 – 2.34) (Not accept: $k_1 = 0.43k$, $k = \frac{k_1}{0.43}$)
(1 mark for correct substitution and 1 mark for the answer)

(iii) (1) 3/2 OR 1.5 1

(2) $mol^{-1.5}\ dm^{4.5}\ s^{-1}$ OR $mol^{-3/2}\ dm^{9/2}\ s^{-1}$ 1
(Accept: 'min' or 'h' instead of 's', Not accept: 'M' instead of 'mol dm^{-3}')

(b) (i) $N_2(g)$ and $H_2(g)$ need to be purified for preventing the catalyst from being poisoned. / remove (catalytic) poisons/CO_2/H_2O. 1
(Not accept: remove pollutants / pollute catalyst / reduce cost/wastage / heat up reactants)

(ii) Do not waste any $N_2(g)$ / and $H_2(g)$ left. / To conserve/save/recycle reactants. 1
(Accept: 'reactants/chemicals/reagents' instead of '$N_2(g)$/ and $H_2(g)$'
Not accept: increase the yield/amount of NH_3)

(iii) NH_3 has a higher boiling point than N_2 / and H_2 (other gases / others). / N_2 / and H_2 (other gases / others) have a lower boiling point than NH_3 / NH_3 is easier to condense than N_2 / and H_2(other gases / others) 1
(A comparative sense)

(iv) (1) (finely divided) iron / Fe / oxides of iron / FeO / Fe_2O_3 / Fe_3O_4 1

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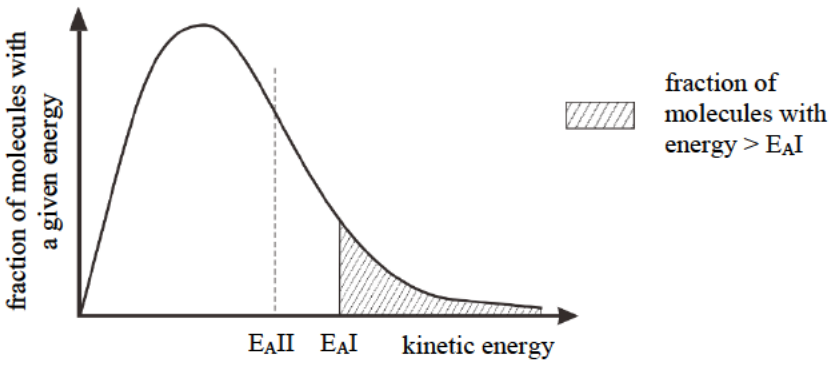
Marks

1. (b) (iv) (2)



4

2 marks for the diagram and 2 marks for explanation.
Diagram:
Shape of the curve (start at 0; Not accept: more than one curve for catalysed and uncatalysed reactions) (1)
Labeling axes (No need to consider E_AII and E_AI) (x-axis: (kinetic) energy, Not accept: potential energy) (y-axis: number of molecules/particles / fraction of molecules/particles) (1)

- When a catalyst is added, the reaction would proceed in an alternative pathway with lower activation energy (E_AII). (Not accept: the activation energy decreased) (1)
- For the pathway with lower activation energy (E_AII), more particles would possess sufficient kinetic energy to react than that in the original pathway with higher activation energy (E_AI). / Number of effective collisions per unit time is thus greater. (1)
  (The reaction pathway with smaller activation energy will proceed faster at the same temperature. The time to reach equilibrium will be shortened.)

(c) (i) Methanol is toxic / flammable. 1

(ii) Landfill site / municipal waste / biomass / organic waste / crude oil / petroleum / biogas / combustible ice (Not accept: coal / LPG / cracking of naphtha) 1

(iii) (1)

- Percentage conversion / yield increases as temperature increases (under constant pressure.) 1
- The forward reaction is endothermic because a higher temperature will shift the equilibrium position to the product side / CO / H_2 to increase the percentage conversion / yield / CO / H_2. (i.e. 1 mark for endothermic + explanation) 1

(2)

- Percentage conversion decreases as pressure increases (under constant temperature.) 1
- $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ (Accept "→"; Not accept "⇒") 1
  The no. of mole of gaseous products (4 moles) is more than the no. of moles of gaseous reactants (2 moles), an increase in pressure will shift the equilibrium position to the reactant / left side to decrease the percentage conversion / yield / CO / H_2. (i.e. 1 mark for chemical equation + explanation) (Accept: the balanced chemical equation presented in part (c)(iii)(1))

(iv) $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ 1
(Accept "→" instead of "⇌"; Not accept "⇒")
(State symbols not required) (Ignore incorrect state symbols)

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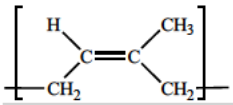
Marks

2. (a) (i)
- Cellulose consists of numerous hydroxyl groups (–OH groups) that can interact strongly / form strong hydrogen bonds with water molecules, this renders its dissolution in water. 1
- Chitin consists of strong hydrogen bonds between C=O and N–H groups of the adjacent chains, this hinders its dissolution in water. 1

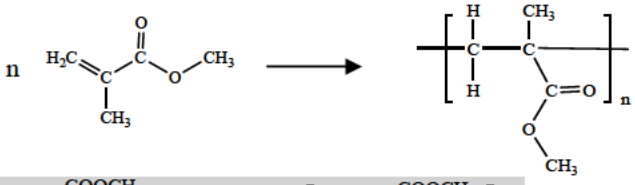
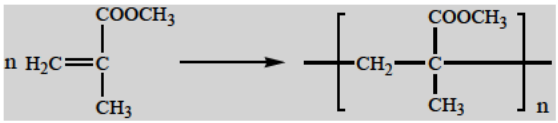
(ii) Liquid crystal display (LCD) / Liquid crystal thermometer 1
(Accept other reasonable answers)

(iii) (1)  1
—[—$CH_2C(H)=C(CH_3)CH_2$—]—

(2) elasticity / tensile strength / hardness / weather resistance / rigidity 1
(Accept: physical property only) (Not accept: 'melting point')

(b) (i) The atom economy of the synthesis
= [100 ÷ (58.0 + 27.0 + 98.1 + 32.0)] × 100%
= [100 ÷ 215.1] × 100% 1
= 46.5% (Not accept: 47%)

(ii) Not green, as the synthesis uses highly toxic HCN / toxic CH_3OH / highly corrosive H_2SO_4 1

(iii) 1


(1)

(iv) (1) Thermosetting polymers are plastics that cannot be softened/melted again by heating (once set hard). / Plastics that can be moulded once only. 1

(2) PMMA is not a thermosetting plastic because its molecules are held by weak van der Waals' forces / without cross-links. 1

(v)
- PMMA has a high light transmittance. / PMMA is transparent. 1
- It is used as artificial glass / optical lens / contact lens / safety goggles. 1

(c) (i) (1)
- Advantage: Corn starch is a renewable resource. (Accept: 'non-toxic') 1
(Not accept: 'biodegradable')
- Disadvantage: Use of corn starch for making PLA may reduce the food supply. / To grow more corn crops may lead to deforestation. 1

(2) There are many ester groups in PLA. 1
These ester groups can be broken down in acidic / alkaline / bacterial conditions, so it is biodegradable. 1

(ii) (1) Chromium / Cr 1

(2)
- Carbon / C (Not accept: 'graphite') 1
- The presence of the carbon atoms in the 'holes' of the lattice greatly hinders the sliding of the layers of atoms over each other. This can increase the hardness of stainless steel. 1

(3) 12 1

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Chemical equations must be balanced. State symbols are optional. Give mark even the state symbols are not correct.

Marks

3. (a) (i)
- Add $NH_3(aq)$ to the two solutions separately until in excess. 1
- $Al_2(SO_4)_3(aq)$: a white ppt insoluble in excess $NH_3(aq)$. $ZnSO_4(aq)$: a white ppt soluble / and then a (clear) solution is formed in excess $NH_3(aq)$. 1

OR

- Add excess $NH_3(aq)$. (1)
- Only $Al_2(SO_4)_3(aq)$ gives a white precipitate. (1)

[If observation wrote "Only $ZnSO_4(aq)$ gives a white ppt which redissolves to form a colourless solution." 0 mark for observation]

OR

- Add Al(s). (1)
- Only $ZnSO_4(aq)$ gives (silvery / grey) solid deposits. (1)

1 mark for correct reagent and 1 mark for correct observation

(ii)
- Reagent and conditions: $Na_2CO_3(aq)$ / $NaHCO_3(aq)$ / $Mg(s)$ / $Na_2CO_3(s)$ / $NaHCO_3(s)$ is added to $CH_3CO_2H(l)$ + water / $CH_3COOH(aq)$ 1
- Observation: $CH_3COOH(l)$ gives out a (colourless) gas. No observable change for $(CH_3)_3COH(l)$. 1

(If no water is added, no mark for reagent but can give mark to correct observation)

OR

- Reagent and conditions: Add a specific alcohol / carboxylic acid + acid catalyst (1)
- Observation: a fruity smell for CH_3CO_2H / $(CH_3)_3COH$ but the other does not. (1)

(If alcohol/carboxylic acid not specific or not mention acid catalyst, no mark for reagent but can give mark to correct observation (fruity smell).

OR

- Reagent and conditions: Add conc. HCl(aq) (+ $ZnCl_2(aq)$ catalyst) (1)
- Observation: Only $(CH_3)_3COH$ forms 2 immiscible liquid layers. (1)

(A comparative sense)

(iii) Orange / yellow / red precipitate / solid 1

(b) (i)
- Add $Na_2CO_3(aq)$/$NaHCO_3(aq)$/$NaOH(aq)$ to the crude sample in the separating funnel. Shake and release the pressure from time to time. 2

(1 mark for separating funnel and 1 mark for adding the correct reagent)
(Accept: adding a suitable organic solvent)

- Discard the lower layer / aqueous layer. OR 1
  Collect the upper layer / organic layer.
  (Accept: Discard the upper aqueous layer OR Collect the lower organic layer).
  (If the reagent is wrong, no mark for this step.)

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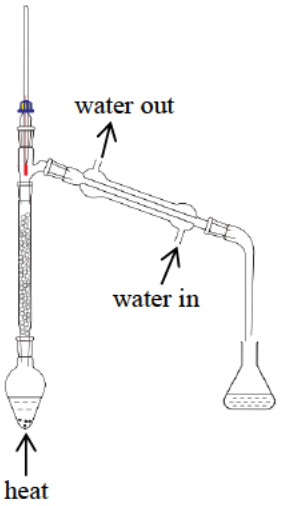
Marks

3. (b) (ii) (1) 2



(1 mark for the sketch: including the pear-shaped flask, fractionating column (with something inside), thermometer, condenser, adapter and a container (such as conical flask, beaker) (Accept: space with thermometer inserted/close system)
(1 mark for labels: water in, water out (Accept arrows), heat)

(2) • Boiling point = 83 °C and shows a peak at 1610 – 1680 (cm^{-1}) corresponding to cyclohexene. 1
• No (broad) peak at 3230 –3670 (cm^{-1}) corresponding to cyclohexanol is shown. 1
(For IR, can state a number in the range. If write cm instead of cm^{-1}, no mark will be given once (i.e. can still give mark for the second same mistake if the wavenumber is correct))

(c) (i) Ratio of C : H : O = 70.6/12 : 5.9/1 : 23.5/16 1
= 4 : 4 : 1 (1)
From the mass spectrum, relative molecular mass of **A** = m/z ratio of the molecular ion = 136
Molecular formula is $C_8H_8O_2$ (with deduction, accept calculations as a means of deduction) 1

(ii) The peak at m/z = 105 corresponds to $C_6H_5CO^+$ / implies that it contains C_6H_5CO group / fragment. (Not accept: $C_7H_5O^+$) 1
(If other peaks mentioned are wrong, no mark for deduction.)
The structure of **A** is $C_6H_5COOCH_3$. 1

(iii) (1) $C_6H_5COOCH_3(l) + NaOH(aq) \rightarrow C_6H_5COONa(aq) + CH_3OH(aq)$ 1
(State symbols not required)
(Accept: any chemical equation for ester hydrolysis. e.g. RCO_2R' as the ester)
(Accept: ionic equation)

(2) No. of moles of HCl(aq) used = 0.05 × 0.0204 1
= 0.00102 = No. of moles of excess NaOH(aq)
No. of moles of NaOH(aq) added = 0.06 × 0.05 = 0.003
No. of moles of **A** = 0.003 – 0.00102 = 0.00198 1*
mass of **A** = 0.00198 × 136 = 0.26928 g
% by mass of **A** in the sample = 0.26928 / 2.75 = 9.79% 1
(range 9.77 – 9.82 1 – 3 decimal places)

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