Paper 2

Marks

1. (a) (i) (1) x --- molecular kinetic energy 1
y --- fraction / percentage of molecules 1

(2) An increase in temperature from T_1 to T_2 will increase the average kinetic energy of the molecules. 1
This will increase the collision frequency and result in greater effective collisions among molecules. 1
There is a larger portion of molecules will have kinetic energy greater than E_a. 1

(ii) $\log k = \text{constant} - \frac{E_a}{2.3RT}$ 3

Slope of curve $= -\frac{E_a}{2.3R}$

$= -1.73 \times 10^3$

$E_a = 1.73 \times 10^3 \times (8.31 \text{ J K}^{-1} \text{ mol}^{-1}) \times 2.3$

$= 33.1 \text{ kJ mol}^{-1}$

(b) (i) A catalyst provides an alternative pathway with lower activation energy. 1

(ii) Concentrated H_2SO_4
Dilute H_2SO_4 contains a lot of H_2O. Water can shift the equilibrium position to the left / cause hydrolysis of eugenol benzoate, and thus lowers the yield of the product. 1
Or: conc. H_2SO_4 is a dehydrating agent / removes water from the product side of the reaction, and will shift the equilibrium position to the right.

(iii) Homogeneous catalyst --- H_2SO_4 is readily available 1
Heterogeneous catalyst --- can be reused / easily be regenerated / easily be separated 1

(c) (i) Chlorine can be produced by electrolysis of brine / concentrated sodium chloride solution using flowing mercury cell / diaphragm cell / membrane cell. 1
Cl^- (aq) ions are discharged at the anode to give Cl_2(g). 1
Diaphragm cell / membrane cell:
H^+(aq) ions are discharged at the cathode. With the removal of Cl^-(aq) ions and H^+(aq) ions, the resultant electrolytic solution contains NaOH(aq) in high concentration. 1
OR Flowing mercury cell:
Sodium amalgam produced at cathode reacts with water forming NaOH(aq).

(ii) Method 2:

Atom economy $= \frac{58}{76} = 76.32\%$ 1

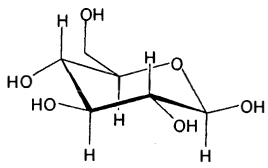
(iii) Method 2 is greener.
Any two of the following: 2
--- It has a higher atom economy.
--- It produces less waste (less side products) and less treatment is required.
--- Less hazardous chemicals are used (method 1 uses more toxic Cl_2).

(iv) The calculation of atom economy is based on a 100% completed reaction. Most reactions do not go to completion and the yield is related to the extent of reaction. 1
Thus a reaction with high atom economy does not necessarily have a high yield. 1

Marks

2. (a) (i) (1) A condensation polymer is a polymer which when formed from its monomers involves the elimination of small molecules. 1

(2) 1



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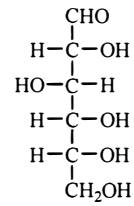

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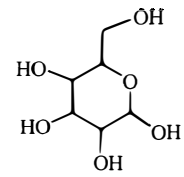
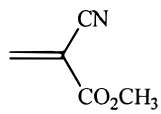


(Accept other correct representations of the structure of glucose.)

(ii) Molecules of cellulose may contain various number of glucose molecules joined together. 1

(iii) Glucose is very soluble in water while cellulose is insoluble in water. 1
A glucose molecule has 5 –OH groups which can attract water molecules strongly via hydrogen bonds. 1
The –OH groups of a cellulose molecule form hydrogen bonds with other cellulose molecules, therefore they are less available to form hydrogen bonds with water molecules. 1

(b) (i) The solid becomes soften upon heating. 1
The heat energy absorbed helps the polymeric molecules to overcome the intermolecular attraction and the molecules can have relative translational motion. 1
At very high temperature, the glue chars / burns. 1

(ii) (1) 

1

(2) Both propanone and poly(methyl 2-cyanoacrylate) are polar organic molecules. 1
The intermolecular attraction in the two compounds is of the same type (polar attraction). Thus, propanone can dissolve poly(methyl 2-cyanoacrylate). 1

(iii) Methyl cellulose is more readily degraded in the environment.
Methyl cellulose is produced from cellulose, a natural material, which is more biodegradable / can be degraded by actions of bacteria or enzymes. 1
Poly(methyl 2-cyanoacrylate) contains long carbon chains which are not readily decomposed. 1

(c) (i) In both nematic phase and smectic phase, the molecules are arranged along one direction. 1
In the smectic phase, the molecules are positionally aligned with each other along a straight line. In the nematic phase, they are not aligned. 1

(ii) Molecule **A** exhibits the cholesteric phase as it is chiral and only chiral compounds can exhibit the cholesteric phase. 1

(iii) The compound solidifies at a very low temperature. 1

(iv) Liquid crystals displays need a backlight source, but OLED displays do not. 1
Liquid crystals act as optical filters to filter off the light from the backlight to give dark spots. Only a small fraction of light passes through them and makes up the images. 1

Marks

3. (a) Use separating funnel to remove water (the lower liquid layer) from the mixture. 1
The upper layer remaining in the funnel is hex-1-ene and octane. 1
Carry out fractional distillation on the upper layer. 1
The first distillate collected is hex-1-ene. The second distillate collected is octane. 1

(b) (i) Any one of the following: 1
--- a significant observable change can easily be detected with the complete consumption of the reagent in the conical flask, i.e. availability of suitable indicator
--- the reaction must be significantly complete
--- the rate of reaction must be fast enough to be practical

(ii) SO_2 easily escapes from solution / I_2 is volatile. 1

(iii) from colourless to dark blue 1

(iv) No. of mole of I_2 used = $0.00412 \times 10.50 \times 10^{-3}$ 4
$= 4.33 \times 10^{-5}$
No. of mole of SO_2 = No. of mole of I_2
$= 4.33 \times 10^{-5}$
Mass of SO_2 in the wine sample = $4.33 \times 10^{-5} \times 64.1$
$= 2.77 \times 10^{-3}$ g
$= 2.77$ mg
Concentration of SO_2 in the wine sample = $\frac{2.77}{0.025} = 111$ mg dm^{-3}

(v) This method cannot be used as the intense red colour of red wine may mask the colour of iodine / iodine-starch complex which leads to a difficulty in the end point detection. 1
Or
This method can be used if the colour of red wine can be removed.

(c) (i) $\frac{2.3}{2.3 + 1.9 + 2.9} = \frac{2.3}{7.1} = 0.32$ 1

(ii) β -carotene because
lycopene has a smaller R_f value / lycopene moves slower / lycopene takes a longer time to reach the bottom of the column. 1

(iii) Method: colorimetry / use of colorimeter 1
Measurement: absorbance / colour intensity 1

(iv) Compound **W** is lycopene. 1
The absence of absorption peaks at around 2070 – 2250 cm^{-1} suggesting it does not contain C≡C groups, ruling out the possibility of compound **X**. 1
The absence of absorption peaks at around 2200 – 2280 cm^{-1} suggesting it does not contain C≡N groups, ruling out the possibility of compound **Y**. 1
OR
The presence of absorption peaks at around 1630 cm^{-1} shows the presence of C=C, ruling out the possibility of compound **Y**.
The absence of sharp absorption peaks at around 3350 – 3500 cm^{-1} suggesting it does not contain $-NH_2$ groups, ruling out the possibility of compound **Z**. 1
Compound **W** is a hydrocarbon which contains only C-H, C-C and C=C bonds. This agrees with the feature of the spectrum as there are small peaks at around 1630 cm^{-1}, showing the presence of C=C.