HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2020

# CHEMISTRY PAPER 2

11:45 am – 12:45 pm (1 hour)
This paper must be answered in English

## INSTRUCTIONS

(1) This paper consists of **THREE** sections, Section A, Section B and Section C. Attempt **ALL** questions in any **TWO** sections.

(2) Write your answers in the **DSE(D)** Answer Book provided. Start each question (not part of a question) on a new page.

(3) A Periodic Table is printed on page 8 of this Question Paper. Atomic numbers and relative atomic masses of elements can be obtained from the Periodic Table.



Not to be taken away before the end of the examination session

**Section A Industrial Chemistry**

Answer **ALL** parts of the question.

1. (a) Answer the following short questions :

(i) Give TWO advantages of a membrane electrolytic cell over a flowing mercury cell in chloroalkali industry.

(2 marks)

(ii) State the catalyst used in the Haber process.

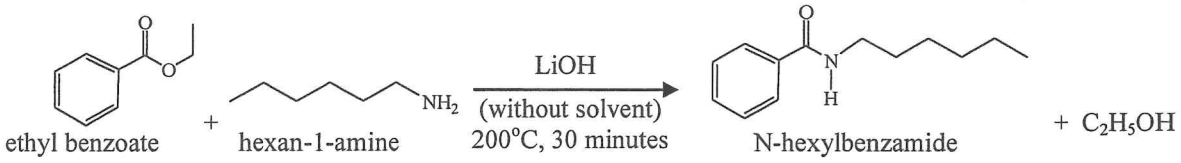
(1 mark)

(iii) Sketch TWO Maxwell-Boltzmann distribution curves for a gaseous sample, one at temperature $T_1$, and the other at a lower temperature $T_2$ (y-axis : number of molecules; x-axis : kinetic energy).

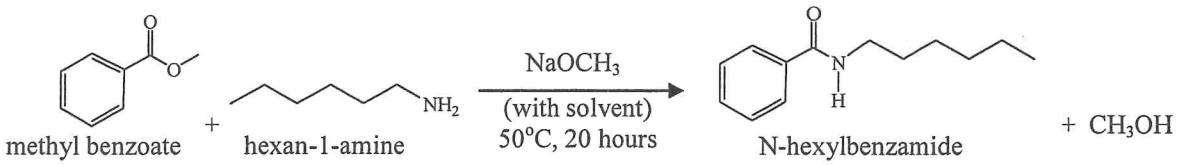
(2 marks)

(b) The two reactions below can produce N-hexylbenzamide :

Reaction (I) :




Reaction (II) :




(i) Based on the above information, suggest one reason for each of the following :

(1) Reaction (I) can be considered as greener than Reaction (II).

(2) Reaction (II) can be considered as greener than Reaction (I).

(2 marks)

(ii) In Reaction (II), 3.00 g of methyl benzoate reacts with 2.23 g of hexan-1-amine to give 3.89 g of N-hexylbenzamide. Calculate the yield of this product.
(Relative molecular masses : methyl benzoate = 136, hexan-1-amine = 101, N-hexylbenzamide = 205)

(2 marks)

(iii) The methanol produced in Reaction (II) can be used to manufacture ethanoic acid in industry by the following reaction :

$$CH_3OH(l) + CO(g) \underset{\text{catalyst}}{\overset{180^\circ C,\ 30\ atm}{\rightleftharpoons}} CH_3COOH(l) \qquad \Delta H < 0$$

(1) According to chemical equilibrium, explain why the operation pressure in industry for the reaction is set at 30 atm but not at atmospheric pressure.

(2) Explain why the optimal operation conditions are set at 180°C and 30 atm.

(3 marks)

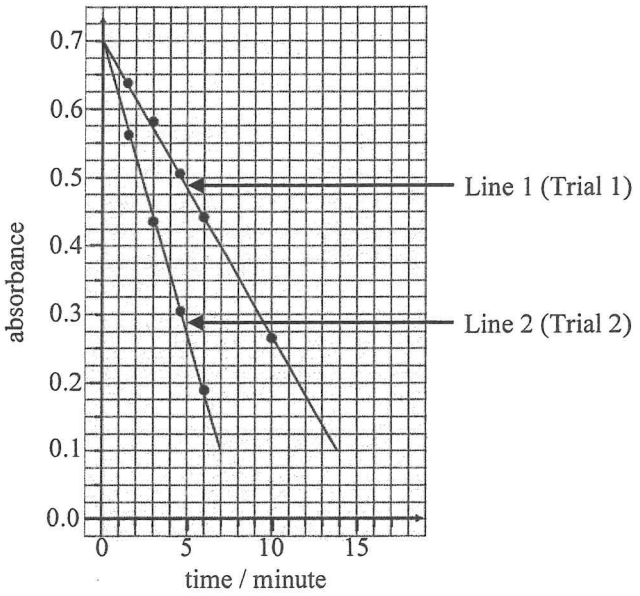
1. (c) Consider the following reaction ($H_2SO_4(aq)$ as catalyst) and its rate equation :

$$CH_3COCH_3(aq) + I_2(aq) \xrightarrow{H^+(aq)} \underset{\text{(colourless)}}{CH_3COCH_2I(aq)} + HI(aq)$$

$$\text{Rate} = k_1[I_2(aq)]^w[CH_3COCH_3(aq)]^x[H^+(aq)]^y \qquad \text{(w, x and y are integers)}$$

Two trials of an experiment were performed under the same experimental conditions to study its chemical kinetics. The table below shows, in the reaction mixture, the initial concentrations of the reagents used; while the graph shows the variation of the absorbance of the reaction mixtures with time :

| Trial | Initial concentration of $CH_3COCH_3(aq)$ / mol $dm^{-3}$ | Initial concentration of $H_2SO_4(aq)$ / mol $dm^{-3}$ | Initial concentration of $I_2(aq)$ / mol $dm^{-3}$ |
|---|---|---|---|
| 1 | 1.0 | 0.10 | 0.0050 |
| 2 | 2.0 | 0.10 | 0.0050 |




(i) Explain why the rate of change of the absorbance can represent the rate of reaction.

(1 mark)

(ii) Under these experimental conditions, the rate equation can be simplified as Rate = $k_2[I_2(aq)]^w$. With reference to Line 1, deduce w.

(2 marks)

(iii) With reference to Line 1 and Line 2, deduce x of the rate equation.

(2 marks)

(iv) Given that y = 1 and the unit of the rate of reaction is mol $dm^{-3}$ $s^{-1}$, what is the unit of the rate constant $k_1$ ?

(1 mark)

(v) It is proposed that the reaction proceeds consecutively in two steps and is exothermic :

$CH_3COCH_3(aq) \rightleftharpoons CH_3C(OH)=CH_2(aq)$ slow

$CH_3C(OH)=CH_2(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$ fast

Draw an energy profile for the reaction. Label the axes.

(2 marks)

**END OF SECTION A**



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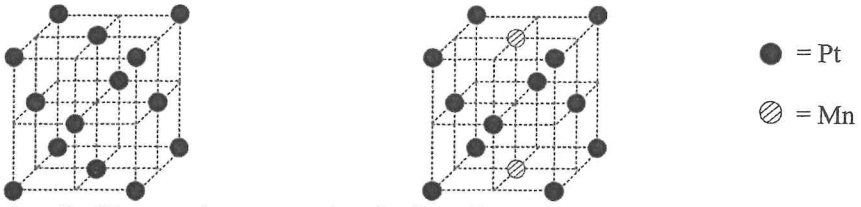
**Section B Materials Chemistry**

Answer **ALL** parts of the question.

2. (a) Answer the following short questions :

(i) Consider the two unit cells in the diagram below :




unit cell of Pt crystal unit cell of an alloy made from Pt and Mn

(1) Name the type of the crystal structure for Pt.

(2) Deduce the respective number of Pt atoms and Mn atoms in the unit cell of the alloy.

(3 marks)

(ii) Silver nanomaterial has different applications.

(1) What is meant by the term 'nanomaterial' ?

(2) Suggest an application of silver nanomaterial in daily life.

(2 marks)

(b) Shields can be made of different materials such as iron, alloy and Kevlar.

(i) In terms of bonding and structure, explain why iron is malleable and ductile.

(2 marks)

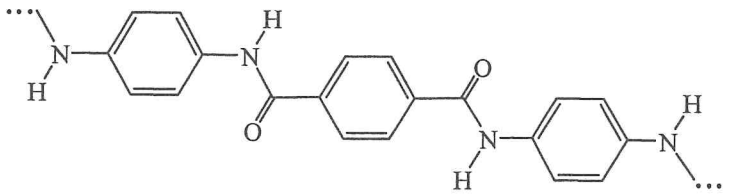
(ii) Adding carbon into iron can make an alloy. The performance of a shield made from an alloy obtained by this method is better than that of an iron shield.

(1) Suggest a physical property of a shield that can be improved in the above method.

(2) Explain, from atomic level, why this physical property can be improved.

(2 marks)

(iii) Bullet-proof shield can be made from Kevlar. The diagram below shows a portion of the structure of Kevlar :

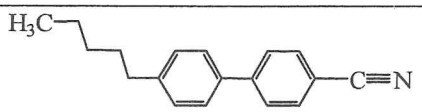
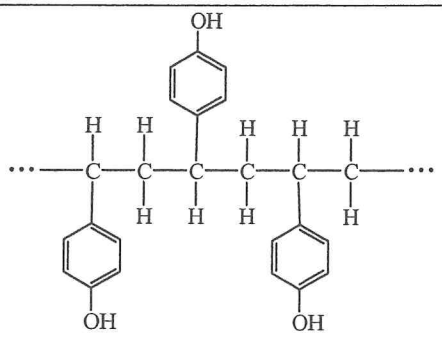
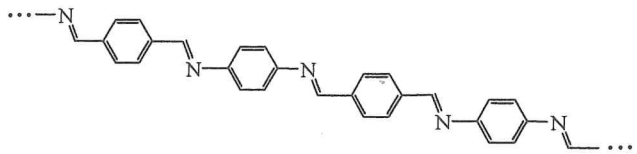


(1) With reference to the structure, give TWO reasons why Kevlar is rigid.

(2) Explain whether there is any chemical reaction when Kevlar is treated with acids.

(3 marks)

2. (c) Part of the structures of liquid crystal **A**, polymers **B** and **C** are shown below :

| | |
|---|---|
| Liquid crystal **A** |  |
| Polymer **B** |  |
| Polymer **C** |  |

(i) State TWO structural characteristics of a molecule of liquid crystal **A**.

(2 marks)

(ii) **B** is an addition polymer.

(1) Draw the structure of the monomer of **B**.

(2) Suggest a moulding method for making a thin film from **B**.

(2 marks)

(iii) **C** is a condensation polymer made from the two monomers below :

Water is formed in this polymerisation.

(1) Draw the structure of the repeating unit of **C**.

(2) Suggest why **C** is classified as a condensation polymer.

(3) Give TWO reasons why this polymerisation can be considered as green.

(4 marks)

**END OF SECTION B**



Go on to the next page

**Section C Analytical Chemistry**

Answer **ALL** parts of the question.

3. (a) Answer the following short questions :

(i) Suggest how $Na_2CO_3(s)$ and $Na_2CO_3 \cdot 10H_2O(s)$ can be distinguished.

(2 marks)

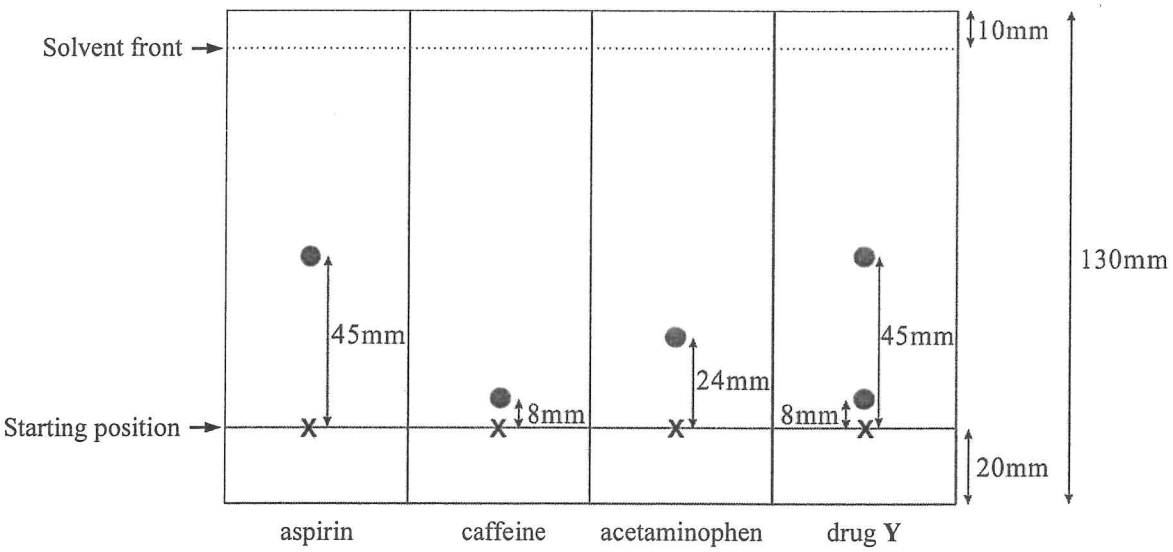
(ii) In an acidified medium, $I_2(aq)$ in a conical flask is titrated with $Na_2SO_3(aq)$ using starch solution as indicator. State the colour change at the end point of the titration.

(1 mark)

(iii) Suggest a chemical test to show how hex-1-ene and hexanal can be distinguished.

(2 marks)

(b) The chromatograms from thin-layer chromatography (TLC) of aspirin, caffeine, acetaminophen and a drug **Y** are shown below.




(i) Draw a labelled diagram for the set-up in performing a TLC experiment.

(2 marks)

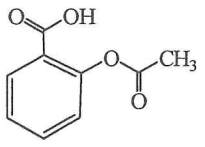
(ii) Calculate the $R_f$ value for aspirin.

(1 mark)

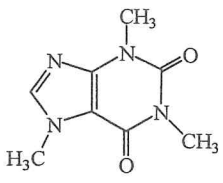
(iii) Based on the chromatograms provided, suggest whether drug **Y** would contain aspirin, caffeine or acetaminophen.

(1 mark)

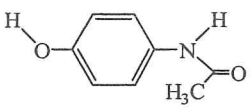
(iv) Consider the following structures :



aspirin



caffeine



acetaminophen

3. (b) (iv) (1) With reference to the table below, suggest how aspirin and caffeine can be distinguished from their infra-red spectra.

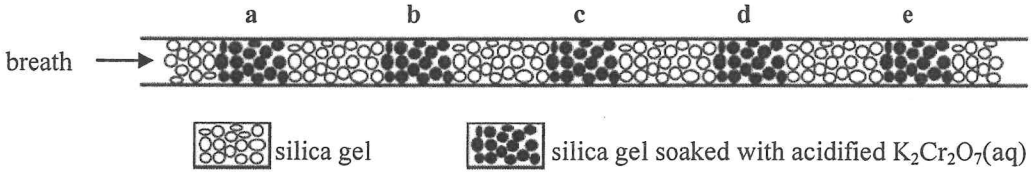
**Characteristic Infra-red Absorption Wavenumber Ranges (Stretching modes)**

| Bond | Compound type | Wavenumber range / $cm^{-1}$ |
|---|---|---|
| C=C | Alkenes | 1610 to 1680 |
| C=O | Aldehydes, ketones, carboxylic acids and derivatives | 1680 to 1800 |
| C≡C | Alkynes | 2070 to 2250 |
| C≡N | Nitriles | 2200 to 2280 |
| O–H | Acids (hydrogen-bonded) | 2500 to 3300 |
| C–H | Alkanes, alkenes, arenes | 2840 to 3095 |
| O–H | Alcohols (hydrogen-bonded) | 3230 to 3670 |
| N–H | Amines | 3350 to 3500 |

(2) A pure sample may be aspirin, caffeine or acetaminophen. There is a major peak at m/z = 43 in the mass spectrum of the sample. Explain whether this information can confirm that the sample is aspirin, caffeine or acetaminophen.

(3 marks)

(c) Road checking on ethanol intake of a driver can be done by having the driver exhale a breath into the tube as shown below :




(i) (1) Suggest the colour change of the silica gel soaked with acidified $K_2Cr_2O_7$(aq) if enough ethanol-contained breath is exhaled into the tube. Write a half equation for the colour change involved.

(2) A breath from driver **A** only changes colour at positions **a** and **b**; while a breath from driver **B** changes colour at positions **a**, **b** and **c**. Assuming the checking is performed in a fair manner, explain which driver has a higher ethanol intake.

(3) Suggest how the checking can be performed in a fair manner.

(4 marks)

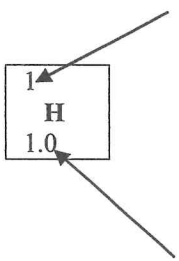
(ii) In a certain country, a driver would be found guilty if the ethanol content in his / her blood exceeds '55 mg of ethanol per 100 $cm^3$ of serum'. 10.0 $cm^3$ of a treated serum sample obtained from the blood of a driver requires 4.38 $cm^3$ of 0.025 mol $dm^{-3}$ $K_2Cr_2O_7$(aq) in an acidified medium for complete reaction. Given that the mole ratio of $C_2H_5OH$(aq) to $K_2Cr_2O_7$(aq) is 3 : 1 in the reaction, calculate the mass of $C_2H_5OH$, in mg, in the serum sample. Determine whether the driver would be found guilty.
(Relative atomic masses : H = 1.0, C = 12.0, O = 16.0)

(4 marks)

**END OF SECTION C**
**END OF PAPER**

# PERIODIC TABLE 周期表

**GROUP 族**




| I | II | | | | | | | | | | | III | IV | V | VI | VII | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | 2 **He** 4.0 |
| 3 **Li** 6.9 | 4 **Be** 9.0 | | | | | | | | | | | 5 **B** 10.8 | 6 **C** 12.0 | 7 **N** 14.0 | 8 **O** 16.0 | 9 **F** 19.0 | 10 **Ne** 20.2 |
| 11 **Na** 23.0 | 12 **Mg** 24.3 | | | | | | | | | | | 13 **Al** 27.0 | 14 **Si** 28.1 | 15 **P** 31.0 | 16 **S** 32.1 | 17 **Cl** 35.5 | 18 **Ar** 40.0 |
| 19 **K** 39.1 | 20 **Ca** 40.1 | 21 **Sc** 45.0 | 22 **Ti** 47.9 | 23 **V** 50.9 | 24 **Cr** 52.0 | 25 **Mn** 54.9 | 26 **Fe** 55.8 | 27 **Co** 58.9 | 28 **Ni** 58.7 | 29 **Cu** 63.5 | 30 **Zn** 65.4 | 31 **Ga** 69.7 | 32 **Ge** 72.6 | 33 **As** 74.9 | 34 **Se** 79.0 | 35 **Br** 79.9 | 36 **Kr** 83.8 |
| 37 **Rb** 85.5 | 38 **Sr** 87.6 | 39 **Y** 88.9 | 40 **Zr** 91.2 | 41 **Nb** 92.9 | 42 **Mo** 95.9 | 43 **Tc** (98) | 44 **Ru** 101.1 | 45 **Rh** 102.9 | 46 **Pd** 106.4 | 47 **Ag** 107.9 | 48 **Cd** 112.4 | 49 **In** 114.8 | 50 **Sn** 118.7 | 51 **Sb** 121.8 | 52 **Te** 127.6 | 53 **I** 126.9 | 54 **Xe** 131.3 |
| 55 **Cs** 132.9 | 56 **Ba** 137.3 | 57 * **La** 138.9 | 72 **Hf** 178.5 | 73 **Ta** 180.9 | 74 **W** 183.9 | 75 **Re** 186.2 | 76 **Os** 190.2 | 77 **Ir** 192.2 | 78 **Pt** 195.1 | 79 **Au** 197.0 | 80 **Hg** 200.6 | 81 **Tl** 204.4 | 82 **Pb** 207.2 | 83 **Bi** 209.0 | 84 **Po** (209) | 85 **At** (210) | 86 **Rn** (222) |
| 87 **Fr** (223) | 88 **Ra** (226) | 89 ** **Ac** (227) | 104 **Rf** (261) | 105 **Db** (262) | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | 58 **Ce** 140.1 | 59 **Pr** 140.9 | 60 **Nd** 144.2 | 61 **Pm** (145) | 62 **Sm** 150.4 | 63 **Eu** 152.0 | 64 **Gd** 157.3 | 65 **Tb** 158.9 | 66 **Dy** 162.5 | 67 **Ho** 164.9 | 68 **Er** 167.3 | 69 **Tm** 168.9 | 70 **Yb** 173.0 | 71 **Lu** 175.0 |
| ** | 90 **Th** 232.0 | 91 **Pa** (231) | 92 **U** 238.0 | 93 **Np** (237) | 94 **Pu** (244) | 95 **Am** (243) | 96 **Cm** (247) | 97 **Bk** (247) | 98 **Cf** (251) | 99 **Es** (252) | 100 **Fm** (257) | 101 **Md** (258) | 102 **No** (259) | 103 **Lr** (260) |