2017-DSE
CHEM
PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2017

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 :

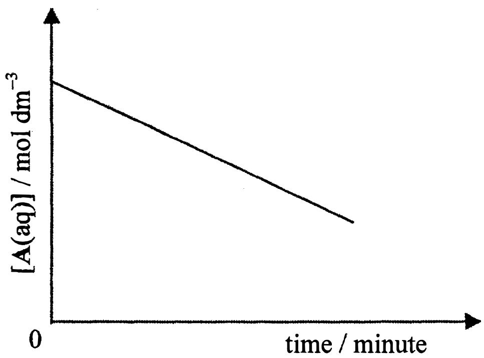
(i) Consider the Haber process :

(1) Write a chemical equation for the reaction.

(2) Suggest how ammonia can be separated from the reaction mixture obtained.

(2 marks)

(ii) The following graph shows the variation of the concentration of a reactant **A**(aq) in a certain reaction at a fixed temperature with time :



Suggest, with explanation, the order of reaction with respect to **A**(aq).

(2 marks)

(iii) Suggest a potential hazard for storing methanol in a chemical plant.

(1 mark)

(b) The manufacture of sulphuric acid involves the following conversion of $SO_2(g)$ to $SO_3(g)$:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

(i) Nitrogen oxides (NO and NO_2) were once used as catalysts for the conversion, and the catalytic process is considered to consist of the following two steps :

$$SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$$
$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

Draw, in the same sketch, TWO labelled energy profiles (x-axis: reaction coordinate; y-axis: potential energy) for the above conversion: one with nitrogen oxides as the catalysts (using **dotted line** '- - - - -'); the other one without catalysts (using **solid line** '———').

(3 marks)

1. (b) (ii) Nowadays in industry, a solid catalyst vanadium(V) oxide is used for the conversion of $SO_2(g)$ to $SO_3(g)$.

(1) The reactants need to be purified before passing into the reaction chamber containing the catalyst. Why ?

(2) The operation conditions are set at 450 °C and 1 atm to achieve a 96% conversion. Suggest why it is NOT preferable to further increase the conversion percentage by each of the following methods :

(I) lowering the temperature of the reaction system

(II) increasing the pressure of the reaction system

(3) In order to increase the conversion percentage, one of the reactants used is in slight excess. From the perspective of feedstock, which of $SO_2(g)$ or $O_2(g)$ would be in slight excess ? Explain your answer.

(4 marks)

(c) Phosgene ($COCl_2$) is an important chemical. It can be produced from the reaction of CO(g) with $Cl_2(g)$:

$$CO(g) + Cl_2(g) \rightarrow COCl_2(g)$$

(i) Write a chemical equation to show how CO(g) can be obtained from natural gas.

(1 mark)

(ii) Chlorine can be produced by the flowing mercury cell process.

(1) Write the half equation for the change occurring at the anode.

(2) Write the half equation for the change occurring at the cathode.

(3) Explain why the flowing mercury cell process has been gradually phased out.

(3 marks)

(iii) At a certain temperature, if the concentration of CO(g) is doubled while the concentration of $Cl_2(g)$ is kept unchanged, the new rate of reaction will become 2.83 times the original rate. Deduce the order of reaction with respect to CO(g).
(Note : The order of a reaction may NOT be an integer.)

(2 marks)

(iv) Explain separately why the above process of producing $COCl_2(g)$ can be considered

(1) green, or

(2) not green.

(2 marks)

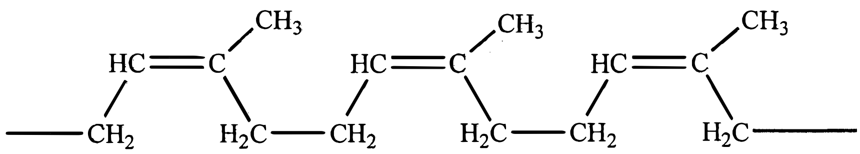
END OF SECTION A

Section B Materials Chemistry

Answer **ALL** parts of the question.

2. (a) Answer the following short questions :

(i) A portion of the structure of natural rubber is shown below :



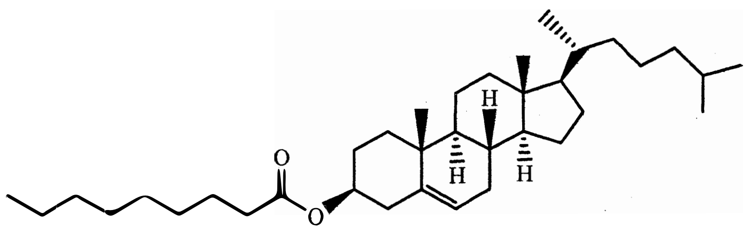
Suggest why natural rubber becomes hardened when it is heated with sulphur.

(2 marks)

(ii) In terms of molecular structure, explain why high density polyethene (HDPE) molecules are more closely packed than low density polyethene (LDPE) molecules.

(1 mark)

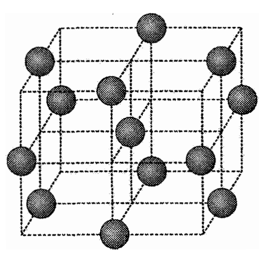
(iii) The structure of compound **A** is shown below :



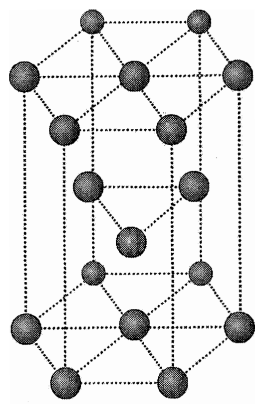
Explain whether **A** would exhibit liquid crystal behaviour.

(2 marks)

(b) The diagrams below show the unit cell of copper crystal and a portion of the structure of zinc crystal :



copper crystal



zinc crystal

(i) Refer to the unit cell of copper crystal.

(1) State the coordination number of a copper atom.

(2) Deduce the number of copper atoms in the unit cell.

(2 marks)

2. (b) (ii) Refer to the portion of the structure of zinc crystal.

(1) Name the type of packing.

(2) State one similarity between the packing of copper crystal and that of zinc crystal.

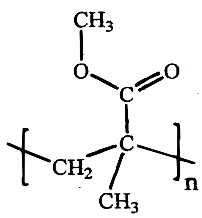
(3) Discuss the difference between the packing of copper crystal and that of zinc crystal.

(4 marks)

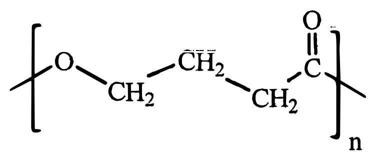
(iii) Name an alloy containing copper and zinc that can be used to make water taps.

(1 mark)

(c) The diagrams below show the structures of Perspex and polyhydroxybutyrate (PHB) :



Perspex



PHB

(i) Draw the structure of the monomer of Perspex, and state the natural raw material for this monomer.

(2 marks)

(ii) Which one of the following items can be made from Perspex ?

rain coat, contact lens, fishing line, food wraps

(1 mark)

(iii) PHB is a thermoplastic polymeric biomaterial.

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

(2) Based on the fact that PHB is a polymeric biomaterial, explain separately why it can be considered environmentally friendly in its production and disposal.

(3 marks)

(iv) PHB can be classified as polyester.

(1) Formation of polyesters often involves condensation. Give a feature of condensation.

(2) Based on the fact that PHB contains ester linkages, explain why it can be considered environmentally friendly in its disposal.

END OF SECTION B

Section C **Analytical Chemistry**

Answer **ALL** parts of the question.

3. (a) Answer the following short questions :

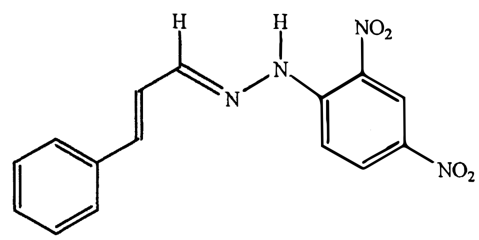
(i) Suggest a test to distinguish between sodium ions and potassium ions.

(2 marks)

(ii) Suggest a chemical test for detecting sulphur dioxide gas.

(2 marks)

(iii) An organic compound **X** reacts with 2,4-dinitrophenylhydrazine to form a yellow solid **Z**. The structure of **Z** is shown below :



Given that the molecular formula of **X** is C_9H_8O, draw the structure of **X**.

(1 mark)

(b) Hydroxylamine ($HONH_2$) reacts with Fe^{3+}(aq) ions under acidic conditions to form products including Fe^{2+}(aq) ions and an oxide of nitrogen. An experiment, consisting of the following two steps, was carried out to deduce the oxidation number of N in the oxide.

Step (1) : An aqueous solution containing 0.875 g of $HONH_2$ and excess $Fe_2(SO_4)_3$ was heated under an acidic condition until the reaction was complete. The resulting solution was then diluted to 250.0 cm^3.

Step (2) : 25.00 cm^3 of the diluted solution was acidified with excess H_2SO_4(aq) and then titrated with 0.0282 mol dm^{-3} $KMnO_4$(aq) until the end point was reached. The chemical equation for the reaction involved is as follows :

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

(i) State the colour change at the end point of the titration.

(1 mark)

(ii) Four trials of the titration were carried out and the results are listed below :

Trial	1	2	3	4
Volume of $KMnO_4$(aq) used / cm^3	38.34	37.62	37.58	37.60

(1) Calculate a reasonable average of the volume of $KMnO_4$(aq) used in the titration.

(2) Based on the experimental results, calculate the mole ratio of $HONH_2$(aq) : Fe^{3+}(aq) required for the completion of the reaction in Step (1).
(Relative atomic masses : H = 1.0, N = 14.0, O = 16.0)

(3) Given that the oxidation number of N in $HONH_2$ is –1, and the oxidation numbers of H and O remain unchanged, deduce the oxidation number of N in the oxide.

(6 marks)

(iii) According to (ii)(3), suggest a reasonable empirical formula for the oxide.

(1 mark)

3. (c) Many plants contain useful organic compounds which can be obtained by extraction using suitable solvents.

(i) The leaf of a certain plant contains a useful organic compound **S**. **S** can dissolve gradually in a warm organic solvent, and can be extracted from the leaves by using this solvent.

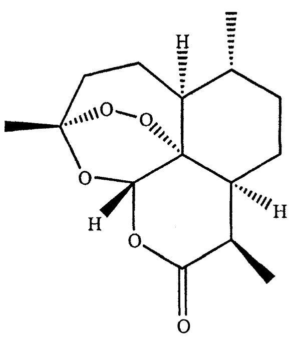
(1) 'Heating under reflux' is a method commonly used to carry out this kind of extraction. State the advantage of this method.

(2) After extraction, the solvent can be removed from the extract by simple distillation. Draw a labelled diagram for the set-up required for this simple distillation.

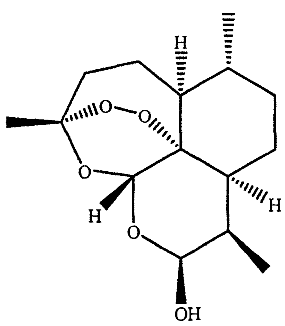
(3) **S** obtained from the extraction may contain other organic impurities. Suggest a method for separating **S** from these impurities.

(4 marks)

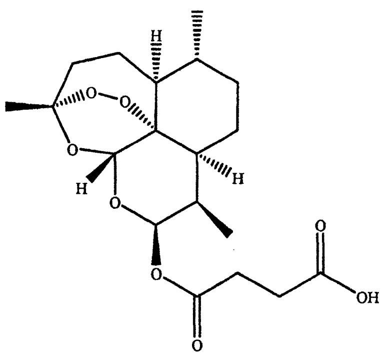
(ii) Artemisinin is an organic compound obtained from a certain plant. Artemisinin cannot react with $NaHCO_3(aq)$. Its infra-red spectrum shows a strong absorption peak at around 1700 cm^{-1}. Suggest which one of **W**, **X**, **Y** and **Z** below would be a possible structure of artemisinin. Explain your answer.



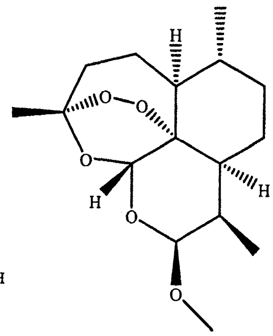
W



X



Y



Z

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

(3 marks)

END OF SECTION C
END OF PAPER

PERIODIC TABLE 周期表

GROUP 族

atomic number 原子序

relative atomic mass 相對原子質量

I	II											III	IV	V	VI	VII	0
				1 **H** 1.0													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)