UNIVERSITY ENTRANCE EXAMINATION 2018

NUS National University of Singapore

Chemistry

Duration : 2 hours

Please read the following instructions carefully.

1. This paper has THREE (3) sections – A, B and C, and comprises FIVE (5) printed pages

2. Attempt all sections. Do not write on the question paper.

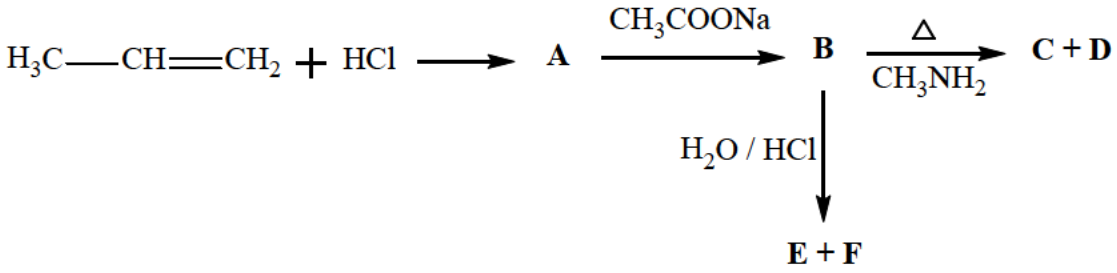
3. Answer all questions in Section A, B and C. Indicate your answers on the answer sheet provided. Write the question number clearly.

4. At the end of the examination, complete the information required on the cover page. Place the cover page on top of your answer sheets and tie them together using the string provided.

5. Do not take any paper, including the question paper or unused answer sheets, out of the examination hall.

Section A (33 marks)
Answer all questions.

1. Consider the following reactions



i) Write the IUPAC name of the starting material.

ii) Provide the structures of the compounds A to F in the above reaction.

(20 marks)

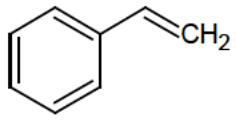
2. Draw the six possible diene isomers of the formula C_5H_8 and give their IUPAC names.

Mention if any of the isomers are conjugated dienes.

(13 marks)

Section B (33 marks)

1. The structure of styrene is given below



The standard heat of combustion of styrene is −4395 kJ/mol.

i) Define standard heat of combustion of a compound.

ii) Write the balanced equation for the combustion of styrene.

iii) Define standard heat of formation of a compound.

iv) Calculate the standard heat of formation of styrene in kJ/mol using the following data: $\Delta H°_f$ of $CO_{2(g)}$ = −393.5 kJ/mol; $\Delta H°_f$ of $H_2O_{(l)}$ = −285.8 kJ/mol

v) Calculate the approximate heat of combustion of styrene in kJ/mol using the bond dissociation energies given below

Type of bond	Average bond dissociation energy $kJmol^{-1}$	Type of bond	Average bond dissociation energy $kJmol^{-1}$
H-H	436	C-O	350
C-H	410	O=O	498
O-H	460	C=C	728
C-C	350	C=O	732
O-O	180	C≡C	965

vi) Compare the calculated value of heat of combustion of styrene with the experimental value of −4395 kJ/mol. Account for any discrepancies.

(20 marks)

2. Natural gas is a mixture of hydrocarbons, primarily methane (CH_4) and ethane (C_2H_6). A typical mixture has the mole fractions of methane and ethane as 0.915 and 0.085 respectively. If 15.85 g of the sample of natural gas has a volume of 12.15 L at a temperature of 24.5°C, then

i) Calculate the total number of moles of gas that is present in the sample.

ii) Calculate the pressure of the sample in atmospheres.

iii) Calculate the partial pressure of each component of the sample in atmospheres.

(13 marks)

Section C (34 marks)

1. Answer the following questions:

   (a) Explain why so many transition element complexes are coloured.

   (3 marks)

   (b) Describe two physical properties of transition metals in which they differ from a typical s-block metal such as potassium.

   (2 marks)

   (c) Anhydrous copper(II) sulphate, $CuSO_{4\,(s)}$, is a white powder which readily dissolves in water. Describe and explain what is seen when $CuSO_{4\,(s)}$ is stirred with water, followed by the addition of $NH_{3\,(aq)}$ until in excess. Write down the relevant balanced chemical equations, including state symbols wherever appropriate.

   (10 marks)

2. NO_2 and O_3 are tri-atomic molecules that contains a dative bond. In the NO_2 molecule, the central atom is nitrogen.

   i) Draw dot-and-cross diagrams to show the bonding in both molecules of NO_2 and O_3. In each case you should distinguish carefully between the electrons originating from the central atom and those from the two outermost atoms. Include all lone pairs in your diagrams.

   ii) Suggest a value for the bond angle in each of the above two molecules, giving reasons for your choice.

   (10 marks)

3. An acidified solution of the salt $KClO_x$ (x = 1, 2 or 3) will oxidise $Fe^{2+}_{(aq)}$ to $Fe^{3+}_{(aq)}$ quantitatively, the chlorine being reduced to $Cl^-_{(aq)}$. When 0.150 g of the salt $KClO_x$ was reacted with 0.500 M $Fe^{2+}_{(aq)}$ in the presence of $H^+_{(aq)}$, 11.3 mL of $Fe^{2+}_{(aq)}$ was needed for complete reaction.

   i) Write down the oxidation states of chlorine in $KClO_x$ for each case when x = 1, 2 and 3.

   ii) Calculate the value of x and construct an equation for the reaction between $Fe^{2+}_{(aq)}$ and acidified $KClO_{x\,(aq)}$.

(9 marks)

END OF PAPER