NCUK

THE NCUK INTERNATIONAL FOUNDATION YEAR

IFYCH002 Chemistry
Examination
2017-18

Examination Session
Semester Two

Time Allowed
2 Hours 40 minutes
(including 10 minutes reading time)

INSTRUCTIONS TO STUDENTS

SECTION A	**Answer ALL questions. This section carries 40% of the exam marks.**
SECTION B	**Answer 3 questions ONLY. This section carries 60% of the exam marks.**

The marks for each question are indicated in square brackets [ ].

- Answers must not be written during the first 10 minutes.
- A data sheet is included in the front of the examination booklet.
- Graph paper will be provided.
- An approved calculator may be used in the examination.
- Show **ALL** workings in your answer booklet.
- Examination materials must not be removed from the examination room.

DO NOT OPEN THIS QUESTION PAPER UNTIL INSTRUCTED BY THE INVIGILATOR

The Periodic Table of the Elements

■ The atomic numbers and approximate relative atomic masses shown in the table are for use in the examination unless stated otherwise in an individual question.

I	II											III	IV	V	VI	VII	0
1.0 **H** Hydrogen 1																	4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulphur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	88.9 **Y** Yttrium 39	91.2 **Zr** Zirconium 40	92.9 **Nb** Niobium 41	95.9 **Mo** Molybdenum 42	98.9 **Tc** Technetium 43	101.1 **Ru** Ruthenium 44	102.9 **Rh** Rhodium 45	106.4 **Pd** Palladium 46	107.9 **Ag** Silver 47	112.4 **Cd** Cadmium 48	114.8 **In** Indium 49	118.7 **Sn** Tin 50	121.8 **Sb** Antimony 51	127.6 **Te** Tellurium 52	126.9 **I** Iodine 53	131.3 **Xe** Xenon 54
132.9 **Cs** Caesium 55	137.3 **Ba** Barium 56	138.9 **La** Lanthanum 57 *	178.5 **Hf** Hafnium 72	180.9 **Ta** Tantalum 73	183.9 **W** Tungsten 74	186.2 **Re** Rhenium 75	190.2 **Os** Osmium 76	192.2 **Ir** Iridium 77	195.1 **Pt** Platinum 78	197.0 **Au** Gold 79	200.6 **Hg** Mercury 80	204.4 **Tl** Thallium 81	207.2 **Pb** Lead 82	209.0 **Bi** Bismuth 83	210.0 **Po** Polonium 84	210.0 **At** Astatine 85	222.0 **Rn** Radon 86
223.0 **Fr** Francium 87	226.0 **Ra** Radium 88	227 **Ac** Actinium 89 †															

Key

relative atomic mass — 6.9 **Li** Lithium

atomic number — 3

140.1 **Ce** Cerium 58	140.9 **Pr** Praseodymium 59	144.2 **Nd** Neodymium 60	144.9 **Pm** Promethium 61	150.4 **Sm** Samarium 62	152.0 **Eu** Europium 63	157.3 **Gd** Gadolinium 64	158.9 **Tb** Terbium 65	162.5 **Dy** Dysprosium 66	164.9 **Ho** Holmium 67	167.3 **Er** Erbium 68	168.9 **Tm** Thulium 69	173.0 **Yb** Ytterbium 70	175.0 **Lu** Lutetium 71
232.0 **Th** Thorium 90	231.0 **Pa** Protactinium 91	238.0 **U** Uranium 92	237.0 **Np** Neptunium 93	239.1 **Pu** Plutonium 94	243.1 **Am** Americium 95	247.1 **Cm** Curium 96	247.1 **Bk** Berkelium 97	252.1 **Cf** Californium 98	(252) **Es** Einsteinium 99	(257) **Fm** Fermium 100	(258) **Md** Mendelevium 101	(259) **No** Nobelium 102	(260) **Lr** Lawrencium 103

* **58 – 71** Lanthanides

† **90 – 103** Actinides

Data Sheet

Infrared spectroscopy: Characteristic absorptions for functional groups	
Bond	**Wave number / cm^{-1}**
C-Br	500 - 600
C-Cl	650 - 800
C-O	1000 - 1300
C=C	1620 - 1670
C=O	1650 - 1750
C=N	2100 - 2250
C-H	2800 - 3100
O-H	2500 - 3550
N-H	3300 – 3500

Section A
Answer ALL questions. This section carries 40 marks.

Question A1

What is the bond angle in the molecule H_2O? **[1]**

a) 109.5º

b) 107º

c) 104.5º

d) 90º

Question A2

How many neutrons are there in an atom of ^{81}Br? **[1]**

a) 35

b) 45

c) 46

d) 81

Question A3

What is the correct electronic structure for sulphur? **[1]**

a) $1s^2 2s^2 2p^6 3s^2 3p^6$

b) $1s^2 2s^2 2p^6 3s^2$

c) $1s^2 2s^2 2p^6 3s^2 3p^2$

d) $1s^2 2s^2 2p^6 3s^2 3p^4$

Question A4

What is the correct electronic structure for a chromium ion, Cr^{3+}? **[1]**

a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$

b) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$

c) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$

d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$

Question A5

What is the trend in solubility of the group 2 metal hydroxides and sulphates as group 2 is descended? **[1]**

a) Hydroxides become less soluble, sulphates become less soluble.

b) Hydroxides become less soluble, sulphates become more soluble.

c) Hydroxides become more soluble, sulphates become more soluble.

d) Hydroxides become more soluble, sulphates become less soluble.

Question A6

Which of the following elements has the highest first ionisation energy? **[1]**

a) Aluminium

b) Silicon

c) Phosphorus

d) Sulphur

Question A7

If bromine water is added to an alkene, what colour change, if any, is observed? **[1]**

a) Orange to green

b) Green to orange

c) Colourless to orange

d) Orange to colourless

Question A8

Which of the following is a covalent compound? **[1]**

a) Sodium chloride

b) Magnesium bromide

c) Sulphur dioxide

d) Calcium oxide

Question A9

The table below contains enthalpy of formation data for the reactants and products in the following reaction. What is the enthalpy change for the reaction? **[1]**

$$C_2H_4 + H_2 \rightarrow C_2H_6$$

	ΔH_f / kJmol^{-1}
C_2H_4	52.5
H_2	0
C_2H_6	-83.7

a) -136.2kJmol^{-1}

b) +136.2kJmol^{-1}

c) -31.2kJmol^{-1}

d) +31.2kJmol^{-1}

Question A10

What are the optimum conditions for the elimination reaction of halogenoalkanes to form alkenes? **[1]**

a) Dilute aqueous NaOH

b) Concentrated ethanolic NaOH

c) Concentrated aqueous NaOH

d) Dilute ethanolic NaOH

Question A11

This question is about molarity and reacting masses.

1.64g of hydrated sodium carbonate $Na_2CO_3.xH_2O$ is dissolved in water and made up to 250cm^3 in a volumetric flask. 25.0cm^3 of this solution required exactly 13.7cm^3 of 0.150moldm^{-3} HCl solution to be neutralised.

a) Calculate the number of moles of HCl in 13.7cm^3 of the 0.150moldm^{-3} HCl solution. **[1]**

b) Hence deduce the number of moles of $Na_2CO_3.xH_2O$ in 25.0cm^3 of the $Na_2CO_3.xH_2O$ solution. Use your answer to calculate the number of moles of $Na_2CO_3.xH_2O$ in the 250cm^3 volumetric flask. **[3]**

c) Use the number of moles you have calculated in (b) and the mass of $Na_2CO_3.xH_2O$ to calculate the Mr of $Na_2CO_3.xH_2O$. Give your answer to 1 decimal place. **[2]**

d) Calculate the Mr of Na_2CO_3 using the periodic table at the beginning of this paper. **[1]**

e) Use your answers from (c) and (d) to find the value of x. **[3]**

Question A12

This question is about alkenes and isomerism.

a) i. Draw the structure of pent-1-ene. **[1]**

ii. Draw and name two isomers of pent-1-ene. **[4]**

b) i. What is the major product when HBr is added to pent-1-ene? **[1]**

ii. Explain why this product is the major product. **[2]**

c) Name a functional group isomer of pent-1-ene. **[1]**

d) Some alkenes exhibit geometrical (E/Z or cis-trans) isomerism. What is the structural feature that gives rise to this kind of isomerism? **[1]**

Question A13

This question is about redox chemistry.

a) i. Define the term 'oxidation' in terms of electrons. **[1]**

ii. State the oxidation number of phosphorus in each of the following compounds:

I PCl_3 **[1]**

II Ca_3P_2 **[1]**

III P_4O_{10} **[1]**

b) When solid sodium iodide is added to concentrated sulphuric acid, the acid reacts with iodide ions to form sulphur dioxide, sulphur, hydrogen sulphide and iodine.

i. Write a half equation to show how hydrogen sulphide is formed from sulphuric acid. **[1]**

ii. Write a half equation to show how iodine is formed from iodide ions. **[1]**

iii. Combine the half equations to give the overall redox equation for the reaction of iodide ions with sulphuric acid to form hydrogen sulphide and iodine. **[1]**

c) Explain why iodide ions are stronger reducing agents than bromide ions. **[3]**

Section B
Answer 3 questions. This section carries 60 marks.

Question B1

This question is about metals and transition metal complexes.

a) Explain what is meant by a "complex ion". **[2]**

b) When cobalt (II) chloride is dissolved in concentrated hydrochloric acid a blue solution forms.

i. Draw a diagram to show the crystal field splitting in the d orbitals of the complex ion formed when cobalt (II) chloride is dissolved in concentrated hydrochloric acid. **[2]**

ii. Use your diagram to explain why the solution is coloured. **[3]**

c) If excess water is added to the cobalt (II) chloride solution described in part b, the colour of the solution changes from blue to pink.

i. Explain this colour change. **[2]**

ii. Analysis of the cobalt complex ion from the solution described in part c)i. gives the composition as 35.3% cobalt, 7.2% hydrogen, with the remainder being oxygen. Calculate the empirical formula of this complex ion. **[3]**

iii. Draw the three dimensional structure of this complex ion, given that its formula is the same as the empirical formula. **[2]**

d) i. Draw a diagram to show how the particles are arranged in a metallic structure. Your diagram should include a minimum of six particles. Show the charges on the particles. **[2]**

ii. Use your diagram to explain why metals can be stretched into wires. **[2]**

iii. Explain why metals are good conductors of electricity. **[2]**

Question B2

a) i. Define the term "electronegativity". **[2]**

ii. State the trend in electronegativity across period 2. Explain this trend. **[3]**

b) i. Define the term "first ionisation energy". **[2]**

ii. State the general trend in first ionisation energies across period 2. Explain this trend. **[3]**

iii. There is an exception to this general trend between groups 2 and 3. Explain this exception to the general trend. **[2]**

iv. Explain why there is also an exception to this general trend between groups 5 and 6. **[2]**

c) i. Describe the structure and bonding in silicon dioxide. **[2]**

ii. Describe the structure and bonding in sulphur dioxide. **[2]**

iii. Explain why silicon dioxide and sulphur dioxide have such different melting and boiling points. **[2]**

Question B3

a) i. Write an equation for the dissociation of propanoic acid including state symbols. **[2]**

ii. Use the equation to explain what is meant by the term **weak acid**. **[1]**

iii. Write an expression for the acid dissociation constant, K_a, for propanoic acid. **[2]**

b) Propanoic acid can be manufactured by reacting ethene, water and carbon monoxide in the following process:

$CH_2CH_2(g) + H_2O(g) + CO(g) \rightleftharpoons CH_3CH_2COOH(g) \quad \Delta H=-167kJmol^{-1}$

If equimolar quantities of CH_2CH_2, H_2O and CO are added together in the gaseous phase at 190ºC and left to reach equilibrium at a pressure of 44.0 atmospheres, the partial pressure of propanoic acid is found to be 17.5 atmospheres when equilibrium is reached.

i. Write an expression for the equilibrium constant K_p. **[1]**

ii) Calculate the partial pressures of CH_2CH_2, H_2O and CO at equilibrium. **[2]**

iii) Calculate the value of K_p for this reaction at 190ºC. Give your answer to 3 significant figures. Include the units in your answer. **[3]**

c) Ammonia can be manufactured by reacting nitrogen and hydrogen in the following process:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H=-92kJmol^{-1}$

i. How should the temperature of the reaction be changed to increase the equilibrium yield of ammonia? Use le Chatelier's principle to explain your answers. **[3]**

ii. How should the pressure of the reaction be changed to increase the equilibrium yield of ammonia? Use le Chatelier's principle to explain your answers. **[3]**

iii. Name three changes which will increase the rate at which this equilibrium is reached. **[3]**

Question B4

This question is about organic compounds.

a) i. Use the data sheet to identify the characteristic absorptions in the IR spectrum of ethanoic acid. **[4]**

ii. I How many peaks would be seen in the ^{1}H NMR of ethanoic acid? **[1]**

II Describe the splitting pattern of the peaks in the ^{1}H NMR of ethanoic acid. **[1]**

b) i. Write an overall equation for the chlorination of ethane and state the conditions required for the reaction to occur. **[2]**

ii. The overall reaction can be broken down into three steps. Name each step of the reaction. Write equations for each step of the reaction. **[5]**

c) Explain the terms **chiral** and **optical activity**. **[2]**

d) Write a mechanism for the reaction of propanal with hydrogen cyanide. Use the mechanism to explain why a mixture of chiral products is obtained. **[5]**

Question B5

a) i. A sample of gold found on a meteorite was found to contain 6.3% ^{195}Au and 93.7% ^{197}Au. Calculate the relative atomic mass of this sample of gold. Give your answer to one decimal place. **[3]**

ii. Give two reasons why samples must be ionised in the mass spectrometer. **[2]**

b) Benzene reacts with concentrated nitric acid in the presence of concentrated sulphuric acid to form nitrobenzene and water.

i. Write the overall equation for this reaction. **[1]**

ii. Concentrated nitric acid reacts with concentrated sulphuric acid to form the species that reacts with benzene. Name this species and write an equation to show how it is formed. **[2]**

iii. Write a mechanism to show the reaction of this species with benzene. **[3]**

iv. Sulphuric acid is reformed during this reaction. Write an equation to show how sulphuric acid is reformed. **[1]**

v. What is the role of the sulphuric acid in this reaction? **[1]**

c) i. Calculate the pH of a 0.150moldm^{-3} solution of benzoic acid if the pK_a of benzoic acid is 4.20. **[5]**

ii. Benzoic acid is insoluble in water. Ethanoic acid is soluble in water. Explain this difference in solubility. **[2]**

This is the end of the examination.

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