Two Hours

UMIST

Chemistry (FY)

2002

The examination consists of three Sections A, B and C. All sections should be answered in one answer book.

Section A This consists of 25 multiple choice questions in which a question is followed by five alternative responses A, B, C, D and E, only one of which is correct. One mark will be awarded for each correct response. All questions should be attempted. You are advised to spend approximately 30 minutes on this Section.

Total25 marks

Section B This consists of four questions that are each worth 10 marks. All questions should be attempted. You are advised to spend approximately 50 minutes on this Section.

Total 40 marks

Section C This consists of three questions **from which you should select ONLY ONE**. You are advised to spend approximately 40 minutes on this Section.

Total 35 marks

Overall total 100 marks

You may use the data booklet provided and electronic calculators, that cannot store text

Section A <u>Answer ALL questions</u>

A1 One of the final steps in the Uranium radioactive decay series is Polonium-210 decaying to Lead-206 as shown below:

 $^{210}_{84}$ Po $\rightarrow \ ^{206}_{82}$ Pb + X

What is the identity of X?

A A neutron **B** An α -particle **C** A β -particle **D** A proton **E** A neutrino

- A2 According to VSEPR theory, the shape of PF₅ may best be described as?
 A Linear B Trigonal C Square Planar D Tetrahedral E Trigonal Bipyramidal
- A3 Which one of the following species is capable of strong intermolecular hydrogen bonding in the liquid state?
 - $\mathbf{A} \ C_6 H_6.$
 - **B** H₂O.
 - C CH₃Cl.
 - \mathbf{D} CH₃OCH₃.
 - E CO₂.
- A4 Which of the following is an atomic electron orbital? A $1p_{xy}$ B $2d_{xy}$ C $3d_{x^2-y^2}$ D $3s_y$ E $2p_{xy}$
- A5 Which of the following molecules exhibits optical isomerism?
 - A 1-bromopentane B 1-bromo-1-chloropentane C 1,1-dichloropentane
 - **D** 1,5-dibromopentane **E** pent-1-ene

- A6 A kinetic study of a reaction in which A reacts to give B and C is carried out. The rate of reaction is found to quadruple if the initial concentration of A is doubled. Which of the following statements about the reaction is true?
 - A The overall order of the reaction is 1.
 - **B** The overall order of the reaction is 4.
 - C The order with respect to reactant A is 1.
 - **D** The order with respect to reactant A is 2.
 - E Order of reaction cannot be deduced from the above information.
- A7 Which of the following statements, concerning S_N1 reactions, is **INCORRECT**?
 - A The reaction is a nucleophilic substitution
 - **B** The reaction involves a carbocation intermediate.
 - C The reaction causes inversion of stereochemistry.
 - **D** The reaction occurs via two simple reaction steps.
 - **E** The rate-determining step is unimolecular.
- A8 Which of the following elements is the **MOST** electronegative?
 - A Br
 B F
 C O
 D S
 E Cl
- A9 Which of the following is not a thermoplastic polymer?

A Polythene	B Polystyrene	C Polyvinylchloride (PVC)
D Polypropylene	E Terylene	

A10 If it takes 100 cm³ of hydrogen gas 1 min to effuse through a tiny hole at 12 °C, roughly how long will it take for 1000 cm³ of oxygen to effuse through the same hole under the same conditions?

A 10 min	B 20 mins	C 30 mins	D 40 mins	E 50 mins
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A11 In the emission spectrum of hydrogen, how many lines may be accounted for by all the possible electron transitions between the five lowest principle quantum levels?
A 6 B 8 C 10 D 12 E 14

A12 Polonium-210 decays with a half-life of 4.5×10^9 yr. How long will it take for the activity of a Polonium-210 sample to be reduced to a quarter of its original value? A 1.1×10^9 yr B 2.2×10^9 yr C 4.5×10^9 yr D 9.0×10^9 yr E 1.8×10^{10} yr

A13 Which of the following species can act as a Lewis acid? **A** N₂ **B** Cl₂ **C** F^- **D** AlCl₃ **E** CCl₄

A14 The reaction between hex-1-ene and ozone can yield which carbonyl products?
A HCHO and CH₃CH₂CH₂CH₂CHO
B CH₃CH₂CHO only
C CH₃COCH₃ only
D CH₃CH₂CH₂CHO and CH₃CHO
E a mixture of many carbonyl products

- A15 Which of the following characteristics is **UNTRUE** of a binary liquid mixture showing a strong negative deviation from Raoult's law?
 - A The total vapour pressure over the mixture is lower than would be expected for an ideal mixture.
 - **B** Mixing the two liquids results in an increase in temperature.
 - **C** The forces between the molecules of the two components are greater than the forces between the molecules within each component.
 - **D** The boiling point-composition diagram of such a mixture will exhibit a maximum boiling point.
 - **E** Regardless of composition, fractional distillation will always yield a distillate richer in the azeotropic mixture.
- A16 Which of the following is NOT a basic assumption of the kinetic theory of gases?A The particles of a given gas have the same kinetic energy at a given temperature.
 - **B** Gas particle size is negligible.
 - C Attractive forces between the gas molecules are negligible.
 - **D** The molecules move in straight lines unless they collide with one another or the container walls.
 - **E** The kinetic energy of the molecules in a gas increases as the temperature increases.

A17 The number of structural isomers of the alkane C_6H_{14} is

A 3	B 4	C 5	D 6	E 7

A18 Which of the following hydrocarbons could be described as saturated?

A but-2-ene.

- **B** but-1-ene.
- C but-1-yne.
- **D** but-2-yne.
- E cyclobutane.
- A19 Which of the following is a colligative property?
 - **A** Polarity.
 - **B** Osmotic pressure.
 - **C** Enthalpy.
 - **D** Acidity.
 - **E** Solubility.
- A20 Which of the following values best approximates to the strength of the carbon-carbon bond in ethane?
 - **A**. 1 kJ mol⁻¹
 - **B**. 10 kJ mol⁻¹
 - **C**. 100 kJ mol⁻¹
 - **D**. 1000 kJ mol⁻¹
 - E. 10000 kJ mol⁻¹
- A21 The partition coefficient of a solid S between heptane and water is 10.0. A solution containing 10.0 g of S in 250 cm³ of water is extracted with 50 cm³ of heptane. What mass of S is extracted from the water?
 - **a** 3.33 g **b** 5.00 g **c** 6.67 g **d** 7.33 g **e** 10.00 g

A22 The initial rate of the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ is A k[N₂(g)][H₂(g)] B k[N₂(g)][H₂(g)]³ C k[N₂(g)]²[H₂(g)]² D k E indeterminable without experimental data

A23 The co-ordination number of an atom in a body centred array is

- **A** 4.
- **B** 6.
- **C** 8.
- **D** 10.
- **E** 12.

A24 The enthalpy change for a process may be defined as:

A
$$\Delta H = \Delta U + p\Delta V$$

B $\Delta H = \Delta V + p\Delta U$
C $\Delta H = \Delta U + \Delta p\Delta V$
D $\Delta H = \Delta V + \Delta p\Delta U$
E $\Delta H = p + \Delta U\Delta V$

A25 Possible quantum number values for an electron occupying a d_z^2 orbital are?

A n = 2, 1 = 0 **B** n = 2, 1 = 1 **C** n = 3, 1 = 0 **D** n = 3, 1 = 1**E** n = 3, 1 = 2

Section B <u>Answer ALL questions</u>

B1 With a suitable diagram, derive the Bragg Equation governing powder X-ray diffraction. 10 marks

B2 Briefly state what you understand by the terms: mass defect; isotope; Boyle's law; allotrope; homolytic fission.

10 marks

- B3 There are eight basic assumptions of the kinetic theory of gases. List five of them.10 marks
- B4 Starting with the ground state electronic configuration of a carbon atom, explain the hybridisation of carbon in ethene. 10 marks

Section C <u>Answer ONLY ONE question</u>

- C1 A compound A $C_5H_{12}O$ is oxidised by acidified potassium dichromate to give B $C_5H_{10}O$. A reacts with concentrated sulphuric acid to yield two isomeric compounds C and D C_5H_{10} . Ozonolysis of C yields propanal and E C_2H_4O . Ozonolysis of D yields methanal and F $C_4H_{10}O$. Treatment of D with hydrogen bromide yields only G $C_5H_{11}Br$. Reflux of G with concentrated aqueous sodium hydroxide yields A once again. Give the names AND structures for compounds A – G. You will gain very little credit unless you FULLY explain your reasoning. 35 marks
- C2 Give detailed descriptions, with appropriate diagrams, of the structures of the following and in each case relate the structure to the physical properties of the material:

a) Diamond	9 marks
b) Graphite	9 marks
c) Metals	9 marks
d) Water	8 marks

C3 Discuss the phenomenon of radioactivity. Your answer should cover the following topics: the existence of isotopes and the belt of stability; the various kinds of radiation; nuclear equations; the kinetics of radioactive decay including the concept of decay constants and half life; and the uses (and associated problems) of radiation.

35 marks