

Two Hours**UMIST****Chemistry (FY)****2003**

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.

Total **25 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.

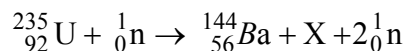
Total **35 marks**

Overall total **100 marks**

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

Section A Answer ALL questions

- A1 The first person ever to split an atom was Hahn in 1937. He bombarded uranium-235 with neutrons. The uranium atoms split apart into two smaller atoms: barium and X and two neutrons, with the release of energy:



What is X?

- A** ${}_{36}^{88}\text{Kr}$ **B** ${}_{36}^{89}\text{Kr}$ **C** ${}_{36}^{90}\text{Kr}$ **D** ${}_{36}^{91}\text{Kr}$ **E** ${}_{36}^{92}\text{Kr}$

- A2 According to VSEPR theory, the shape of PCl_3 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?

- A** C_6H_6
B H_2O
C CH_3Cl
D CH_3OCH_3
E CO_2

- 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-bromohexane **B** 1-bromo-1-chlorohexane **C** 1,1-dichlorohexane
D 1,6-dibromohexane **E** hex-1-ene

A6 A kinetic study of a reaction in which $A + B$ react to give C is carried out. The rate of reaction is found to double if the initial concentration of A is doubled and double if the initial concentration of B 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 2.
- C The order with respect to reactant A is 2.
- D The order with respect to reactant B 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 F B Cl C Br D I E At

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 10 cm^3 of hydrogen gas 1 min to effuse through a tiny hole at 298 K, roughly how long will it take for 100 cm^3 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

A11 In the emission spectrum of hydrogen, how many lines may be accounted for by all the possible electron transitions between the seven lowest principle quantum levels?

- A** 6 **B** 7 **C** 21 **D** 23 **E** 25

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** N_2 **B** Cl_2 **C** F^- **D** AlCl_3 **E** CCl_4

A14 The reaction between hex-1-ene and ozone can yield which carbonyl products?

- A** HCHO and $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$
B $\text{CH}_3\text{CH}_2\text{CHO}$ only
C CH_3COCH_3 only
D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ and CH_3CHO
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. $10000 \text{ kJ mol}^{-1}$

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 cm^3 of water is extracted with 50 cm^3 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 $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ is

A $k[\text{N}_2(\text{g})][\text{H}_2(\text{g})]$

B $k[\text{N}_2(\text{g})][\text{H}_2(\text{g})]^3$

C $k[\text{N}_2(\text{g})]^2[\text{H}_2(\text{g})]^2$

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 $n = 2, l = 0$

B $n = 2, l = 1$

C $n = 3, l = 0$

D $n = 3, l = 1$

E $n = 3, l = 2$

Section B Answer ALL questions

- B1 State Markovnikov's rule for the addition of hydrogen halide to a double bond. Give an explanation for the rule.

10 marks

- B2 Briefly state what you understand by the terms: Balmer series; first ionisation energy; van der Waals forces, alkali metals; empirical formula.

10 marks

- B3 a) State what is meant by the term isotope. **2 marks**

b) Give the symbol and the relative atomic mass of the isotope which is used as the current standard for defining relative atomic masses. **2 marks**

c) State the number of protons, neutrons and electrons in the plutonium isotope, ${}^{234}_{94}\text{Pu}$.

3 marks

d) A radioactive isotope produces a reading of 1200 counts per minute on a Geiger counter. After 46 hours, the count rate has fallen to only 300 counts per minute. Calculate the half-life of the isotope. **3 marks**

- B4 Draw a Lewis structure for ammonia, NH_3 . Use VSEPR theory to predict the molecular shape of ammonia and using the electronic configuration of nitrogen, explain the hybridisation of the nitrogen atom in ammonia. According to the Lewis theory ammonia is basic. Explain why this is so.

10 marks

Section C Answer ONLY ONE question

- C1 Treatment of an alcohol **A**, $C_4H_{10}O$ with concentrated sulphuric acid yielded two isomeric hydrocarbons **B** and **C**, C_4H_8 . Ozonolysis of **B** yielded methanal and **D**, whilst ozonolysis of **C** yielded only one product **E**. The reaction of **B** with hydrobromic acid yielded **F**, C_4H_9Br . **F** was formed in accordance with Markovnikov's rule.

Give names and draw stick structures for compounds **A** – **F**. You will gain very little credit unless you fully explain your reasoning.

30 marks

What kind of isomerism exists between **B** and **C**?

5 marks

- C2 Give detailed descriptions, with appropriate diagrams, of the following metallic structures:

a) cubic close packed (ccp) **6 marks**

b) hexagonal close packed (hcp) **6 marks**

c) body centred cubic (bcc) **6 marks**

d) face centred cubic (fcc) **6 marks**

Give the coordination number for ccp, hcp and bcc. **3 marks**

Water and heptane are both liquids. Discuss the differences between them. **6 marks**

Which liquid would make the best solvent for sodium chloride? **2 marks**

- C3 Starting from quantum numbers and their allowed values, describe the various atomic, electronic orbitals and explain how electrons occupy them. Your answer should explain how quantum numbers lead to our current picture of atomic orbitals. You should discuss the names, shapes and degeneracy of the possible orbitals, the Pauli exclusion principle, the aufbau principle, Hund's rule and electronic configurations. You are NOT expected to discuss any orbital with a principle quantum number greater than 3. **35 marks**