

Two Hours

UMIST

Intengo and Foundation Year Chemistry

1999

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**. 1 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 4 compulsory questions which are each worth 10 marks. You are advised to spend approximately 50 minutes on this Section.

Total **40 marks**

Section C This consists of 3 questions **from which you should select only one**. You are advised to spend approximately 40 minutes on this Section.

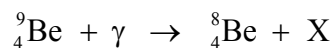
Total **35 marks**

Overall Total **100 marks**

Electronic calculators may be used, provided that they **cannot** store text

Section A Answer ALL questions

A1 A nuclear reaction is represented by the equation



What is the identity of X?

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

A2 Which of the following statements, concerning $\text{S}_{\text{N}}2$ reactions, is **incorrect**?

A The reaction occurs via 2 simple reaction steps.

B The reaction involves a transition state.

C The reaction is accompanied by inversion of stereochemistry.

D The reaction is a nucleophilic substitution.

E The reaction is bimolecular.

A3 The partition coefficient of a solid S between ethoxyethane and water is 3.0. A solution containing 8.0 g of S in 300 cm^3 of water is extracted with 100 cm^3 of ethoxyethane. What mass of S is extracted from the water?

A 2.0 g **B** 4.0 g **C** 6.0 g **D** 8.0 g **E** 10.0 g

A4 How many degenerate d-orbitals are there?

A 1 **B** 3 **C** 5 **D** 7 **E** 10

A5 What is the shape of SF_6 ?

A Linear

B Trigonal planar

C Tetrahedral

D Trigonal bipyramidal

E Octahedral

- A6 Which of the following species can act as a Lewis acid?
A H_2 **B** NH_3 **C** Cl^- **D** BF_3 **E** CHCl_3
- A7 Which of the following molecular formulae corresponds to 2-chloro-3-methylhex-1-ene?
A $\text{C}_6\text{H}_{13}\text{Cl}$ **B** $\text{C}_6\text{H}_{11}\text{Cl}$ **C** $\text{C}_7\text{H}_{12}\text{Cl}_2$ **D** $\text{C}_7\text{H}_{13}\text{Cl}$ **E** $\text{C}_8\text{H}_{12}\text{Cl}_2$
- A8 Which of the following is **not** an addition polymer?
A Nylon 6,6 **B** Polyvinylchloride (PVC) **C** Polystyrene
D Polythene **E** Teflon (PTFE)
- A9 The product of the reaction between hex-3-ene and ozone can yield which carbonyl products?
A HCHO and CH_3COCH_3
B $\text{CH}_3\text{CH}_2\text{CHO}$ only
C CH_3COCH_3 only
D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$ and HCHO
E $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ and CH_3CHO
- A10 If it takes 25 cm^3 of hydrogen gas 2 mins to effuse through a tiny hole at 25°C , how long will it take for 25 cm^3 of oxygen to effuse through the same hole under the same conditions?
A 1 min **B** 2 mins **C** 4 mins **D** 6 mins **E** 8 mins
- A11 How many structural isomers of $\text{C}_5\text{H}_{11}\text{Cl}$ exist?
A 2 **B** 4 **C** 6 **D** 8 **E** 10

A12 In which of the following compounds is the bonding most ionic?

A sodium bromide

B sodium fluoride

C sodium iodide

D sodium chloride

E lithium bromide

A13 In the emission line spectrum of hydrogen, how many lines can be accounted for by all the possible electron transitions between the four lowest principle quantum levels?

A 2

B 4

C 6

D 10

E 18

A14 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.

A15 The half-life of a radioactive isotope is 10 years. To three decimal places, what fraction of the isotope's original radioactivity will remain after a period of 50 years?

A 0.008

B 0.016

C 0.031

D 0.063

E 0.125

A16 Which of the following is **not** a colligative property?

A Depression of freezing point.

B Osmotic pressure.

C Elevation of boiling point.

D Lowering of vapour pressure.

E Solubility.

A17 The rate expression for the reaction between A and B is $\text{rate} = k[\text{A}][\text{B}]^2$.

Which of the following statements about the reaction is **not** true?

A The order of reaction is 2 with respect to B.

B Suitable units for the rate constant are $\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$

C The overall order of the reaction is 3.

D The rate of the reaction is halved by halving the concentration of A.

E The rate of the reaction is doubled by doubling the concentration of B.

A18 Toluene (methylbenzene) undergoes two very different reactions with chlorine, depending upon the conditions. The mechanisms of the two reactions are best described as

A free radical attack and nucleophilic substitution.

B free radical attack and electrophilic substitution.

C nucleophilic addition and free radical attack.

D nucleophilic addition and nucleophilic substitution.

E electrophilic substitution and nucleophilic addition.

A19 In which of the following pairs is the radius of the second atom greater than the first?

A Al and B

B F and Cl

C Si and C

D Na and Li

E P and N

A20 Which of the following is **not** a line series in the emission spectrum of gaseous hydrogen?

A Lyman.

B Balmer.

C Pascal.

D Brackett.

E Pfund.

A21 Which of the following elements has the greatest first ionisation enthalpy?

A Be

B B

C C

D N

E O

A22 An electrophile is best described as?

A A lone pair acceptor.

B An electron-rich species.

C A Lewis base.

D An anion.

E An ideal reagent for reaction with an aldehyde or ketone.

A23 The arrangement of cations in a metal is usually either hexagonal close packing (hcp) or cubic close packing (ccp). In both cases the co-ordination number of the metal cations is

A 6

B 8

C 10

D 12

E 14

A24 A quantity of gas occupies 24.0 dm^3 at 25°C and 101325 Pa . What volume will the gas occupy at 200°C and 150000 Pa ?

A 4.4 dm^3

B 9.5 dm^3

C 25.7 dm^3

D 56.4 dm^3

E 129.7 dm^3

A25 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.

Section B Answer all questions

- B1 Use VSEPR theory to predict the structures of CCl_4 , AlCl_3 , NH_3 , H_2S and CO_2 . You should draw a three dimensional representation of each structure and name the geometry. **10 marks**
- B2 Briefly state what you understand by the terms addition reaction, free radical, canonical form, π -bond and chiral centre. **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 $^{238}_{92}\text{U}$. **3 marks**
d) A radioactive isotope produces a reading of 120 counts per minute on a Geiger counter. After 18 hours, the count rate has fallen to only 15 counts per minute. Calculate the half-life of the isotope. **3 marks**
- B4 Draw and explain the various possible types of curve arising when the vapour pressure of a mixture of two volatile, miscible liquids is plotted against the composition of the mixture. You should refer to the ideal case and also two non-ideal cases. **6 marks**
For the ideal case, draw the boiling point / composition curve. **1 mark**
Show how the curve you have drawn may be used to explain the process of fractional distillation. **3 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.*

Explaining your reasoning, give names and structures for compounds **A – F**. **30 marks**

Explain the significance of the sentence in italics. **5 marks**

- C2 a) State the first law of thermodynamics. **2 marks**

b) The heat change in a reaction can be expressed as ΔH or ΔU . Explain briefly, the distinction between these two quantities. **6 marks**

c) Which of the two quantities ΔH and ΔU is more useful in relation to most chemical reactions? Explain your answer. **4 marks**

d) Construct a Born-Haber cycle for the formation of solid sodium chloride from its elements in their standard states and use the following data to calculate its standard enthalpy of formation. **13 marks**



e) Give names for the five enthalpy changes listed above. **10 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**