

Two Hours

UMIST

Intengo and Foundation Year Chemistry

2000

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.

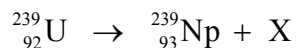
Total **35 marks**

Overall Total **100 marks**

You may use the data booklet provided and electronic calculators, that **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 According to VSEPR theory, the shape of XeF_4 is?

A Linear **B** Trigonal **C** Square Planar **D** Tetrahedral **E** Trigonal Bipyramidal

A3 A free radical is best described as?

A A product of heterolytic fission.

B An anionic species.

C A particularly unreactive species.

D A species with a single unpaired electron.

E A cationic species.

A4 The partition coefficient of a solid S between hexane and water is 5.0. A solution containing 10.0 g of S in 250 cm^3 of water is extracted with 50 cm^3 of hexane. What mass of S is extracted from the water?

A 1.0 g **B** 2.0 g **C** 3.0 g **D** 4.0 g **E** 5.0 g

A5 The explosive TNT is trinitrotoluene. If toluene is methyl benzene, which of the following molecular formulae corresponds to TNT?

A $\text{C}_7\text{H}_5\text{N}_3\text{O}_6$ **B** $\text{C}_6\text{H}_3\text{N}_3\text{O}_6$ **C** $\text{C}_7\text{H}_5\text{N}_3\text{O}_3$ **D** $\text{C}_6\text{H}_3\text{N}_3\text{O}_3$ **E** $\text{C}_7\text{H}_9\text{N}_3\text{O}_6$

A6 The rate expression for the reaction between A and B is, $\text{rate} = k[\text{A}]^2[\text{B}]$.

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

A The reaction is first order 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 quadrupled by doubling the concentration of A.

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

A7 Which of the following statements, concerning $\text{S}_{\text{N}}1$ reactions, is **incorrect**?

A The reaction is a nucleophilic substitution

B The reaction involves a carbocation intermediate.

C The reaction is accompanied by racemisation.

D The reaction occurs via one simple reaction step.

E The rate determining step is unimolecular.

A8 In which of the following pairs is the radius of the second atom greater than the first?

A Be and Mg

B Br and F

C P and N

D S and O

E K and Na

A9 Which of the following is a condensation polymer?

A Polythene

B Polyvinylchloride (PVC)

C Polystyrene

D Nylon 6,6

E Teflon (PTFE)

A10 If it takes 20 cm^3 of oxygen gas 1 min to effuse through a tiny hole at 22°C , how long will it take for 51 cm^3 of carbon dioxide to effuse through the same hole under the same conditions?

A 1 min

B 2 mins

C 3 mins

D 4 mins

E 5 mins

A11 The Universal Gas Constant R is quoted as 8.314 in what units?

- A** J K mol **B** J K⁻¹ mol **C** J K mol⁻¹ **D** J K⁻¹ mol⁻¹ **E** J⁻¹ K⁻¹ mol⁻¹

A12 Carbon dating of archaeological specimens is based on the radio active decay of ¹⁴C which occurs with a half life of 5700 years. To two decimal places, what fraction of the isotope's original radioactivity will remain in a specimen dated at BC 9400?

- A** 0.13 **B** 0.25 **C** 0.50 **D** 0.61 **E** 0.75

A13 Which of the following characteristics is **untrue** of a binary liquid mixture showing a strong positive deviation from Raoult's law?

- A** The total vapour pressure over the mixture is higher 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 lower than the forces between the molecules within each pure component.
D The boiling point-composition diagram of such a mixture will exhibit a minimum boiling azeotropic point.
E Regardless of composition, fractional distillation will always yield a distillate richer in the azeotropic mixture.

A14 Which of the following elements is most electronegative?

- A** Na **B** Al **C** Si **D** P **E** S

A15 The electronic ground state configuration of Cl^+ is?

A $[\text{Ne}] 3s^2 3p^4$.

B $[\text{He}] 2s^2 2p^4$.

C $[\text{Ne}] 3s^2 3p^5$.

D $[\text{Ne}] 3s^2 3p^6$.

E $[\text{Ar}] 4s^2 3d^{10} 4p^4$.

A16 On being subjected to direct sunlight, a solution of chlorine in an organic liquid evolves hydrogen chloride, but in the absence of light this reaction stops. The reaction is likely to proceed *via*

A Electrophilic addition.

B Nucleophilic addition.

C Free radical substitution.

D Nucleophilic substitution.

E Electrophilic substitution.

A17 The number of structural isomers of the alkane C_5H_{12} is

A 2

B 3

C 4

D 5

E 6

A18 Grignard reagents (RMgX) are useful synthetic reagents since they act as a source of

A electrophilic carbon.

B nucleophilic carbon.

C free radical carbon.

D carbocations.

E Magnesium halide.

- A19 The “breathalyser” test used to determine whether or not motorists have consumed too much alcohol requires the the suspect to exhale air through a tube containing acidified orange potassium dichromate (VI). If the exhaled air contains alcohol the crystals turn green. In a positive test the ethanol is
- A** dehydrated to ethene.
 - B** partially dehydrated to ethoxyethane.
 - C** oxidised to ethanal.
 - D** polymerised.
 - E** oxidised to a diol.
- A20 Which of the following reactions does **not** occur by electrophilic substitution?
- A** nitration of toluene.
 - B** methylation of benzene.
 - C** acylation of benzene.
 - D** hydrogenation of benzene.
 - E** chlorination of chlorobenzene.
- A21 The oxidation state of managanese in permanganate MnO_4^- is
- A** 3 **B** 4 **C** 5 **D** 6 **E** 7
- A22 The initial rate of the reaction $2\text{S}_2\text{O}_3^{2-}(\text{aq}) + \text{I}_2(\text{aq}) \rightarrow 2\text{I}^-(\text{aq}) + \text{S}_4\text{O}_6^{2-}$ is
- A** indeterminable without experimental data
 - B** $k[\text{S}_2\text{O}_3^{2-}(\text{aq})]^2[\text{I}_2(\text{aq})]$
 - C** k
 - D** $k[\text{S}_4\text{O}_6^{2-}(\text{aq})][\text{I}^-(\text{aq})]^2$
 - E** $k[\text{S}_2\text{O}_3^{2-}(\text{aq})][\text{I}_2(\text{aq})]$

A23 Hydrogen bonds range in strength from:

A $1 - 2 \text{ kJ mol}^{-1}$

B $2 - 5 \text{ kJ mol}^{-1}$

C $5 - 10 \text{ kJ mol}^{-1}$

D $10 - 40 \text{ kJ mol}^{-1}$

E $40 - 200 \text{ kJ mol}^{-1}$

A24 The Gibbs free energy ΔG for a reaction is defined as:

A $\Delta G = T\Delta S$

B $\Delta G = \Delta H + T\Delta S$

C $\Delta G = \Delta H - T\Delta S$

D $\Delta G = -T\Delta S$

E $\Delta G = \Delta S + T\Delta H$

A25 Which of the following has the highest boiling point?

A hexane

B hex-2-ene

C hexan-2-ol

D cyclohexane

E hex-1-ene

Section B Answer all questions

- B1 (a) Explain the term polymer. **2 marks**
 (b) Write the structural formula of polystyrene. **1 mark**
 (c) To which class of polymers does polystyrene belong? **1 mark**
 (d) Use another member of this class of polymers to diagrammatically represent what you understand by the terms atactic, isotactic and syndiotactic. **3 marks**
 (e) Hexane-1,6-dioic acid and hexane-1,6-diamine polymerise under appropriate conditions to yield nylon 6,6. To which class of polymers does this product belong? **1 mark**
 (f) How does the thermal behaviour of these two types of polymer differ? **2 marks**
- B2 Briefly state what you understand by the terms resonance, colligative property, propagation step, halogen carrier and entropy. **10 marks**
- B3 a) Briefly describe the 3 different types of radiation emitted by unstable radio-nuclides. **6 marks**
 b) Explain the significance of the belt of stability. **2 marks**
 c) Explain the term half-life. **2 marks**
- B4 Draw and name the five degenerate d orbitals. **10 marks**

Section C Answer only one question

- C1 A compound **A** $\text{C}_3\text{H}_7\text{Br}$ reacts with magnesium turnings in dry diethyl ether to yield a compound **B** $\text{C}_3\text{H}_7\text{BrMg}$. **B** reacts with **C**, $\text{C}_3\text{H}_6\text{O}$ to yield the secondary alcohol **D**, $\text{C}_6\text{H}_{14}\text{O}$. Dehydration of **D** with sulphuric acid yields two isomeric compounds **E** and **F** C_6H_{12} . Ozonolysis of **E** yields ethanal and 2-methylpropanal. Ozonolysis of **F** yields **C** and **G**.

Name and give structures for compounds **A – G**. You will gain very little credit unless you fully explain your reasoning. **35 marks**

- C2 a) Give the coordination number of the following metallic lattices:

Hexagonal close packed (hcp) **2 marks**

Cubic close packed (ccp) **2 marks**

Body centred cubic (bcc) **2 marks**

b) Explain why metals are good conductors of electricity. **4 marks**

c) Graphite and diamond are two allotropes of carbon. Describe, with appropriate diagrams, how their differing physical appearances and properties may be related to their structures.

12 marks

d) Water molecules have stronger hydrogen bonding between them than ammonia molecules. Why? **8 marks**

e) Dry ice is solid carbon dioxide. In the solid lattice, the individual carbon dioxide molecules are held together by Van der Waals forces. Explain the origin of these forces and describe their influence upon the melting point of the material. **5 marks**

- C3 a) With reference to the structures of alkanes, alkenes and alkynes discuss the phenomenon of orbital hybridisation. Your answer should include descriptions of electronic configurations and should account for bonding geometries in the above-mentioned classes of compound. **25 marks**

b) Give a **detailed** description of the structure of benzene. **10 marks**