Two Hours

UMIST

Intengo and Foundation Year Chemistry

2001

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.
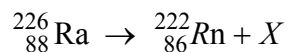
Total	**35 marks**

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 radioactive decay of Radium-226 into Radon-222 occurs as shown below:

$$^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + X$$

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 OCl_2 may best be described as?

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

A3   A Lewis base is best described as?

A An electron pair acceptor.

B An electrophile.

C A cationic species.

D A nucleophile.

E A species with a single unpaired electron.

A4   Which of the following is **NOT** an electron orbital?

A 3s   **B** $2p_x$ **C** $3d_{x^2-y^2}$ **D** $3p_z$ **E** $2d_z^2$

A5   Many modern day antiseptics derive from the molecule hydroxybenzene, known as phenol. Which of the following is the correct formula for phenol?

A C_6H_5O **B** $C_6H_5O_2$ **C** C_6H_6O **D** $C_6H_6O_2$ **E** $C_6H_7O_2$

A6   Chemical Engineering requires knowledge of reaction kinetics. A kinetic study of a reaction in which A reacts with B to give C is carried out. The rate of reaction is found to double if the initial concentration of A is doubled but is unaffected by the initial concentration of B. 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 B is 1.

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_N2 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 one simple reaction step.

E The rate-determining step is bimolecular.

A8   Which of the following elements is the **MOST** electronegative?

A C   **B** N   **C** O   **D** S   **E** Ne

A9   Polymers are of huge importance in materials chemistry and hence in engineering. Which of the following is **NOT** a condensation polymer?

A Nylon 6,6   **B** Polyvinyl chloride (PVC)   **C** Terylene

D Nylon 6,10   **E** Polyester

A10 If it takes 10 cm^3 of nitrogen gas 1 min to effuse through a tiny hole at 12 ˚C, roughly how long will it take for 25 cm^3 of chlorine 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 In the emission spectrum of hydrogen, how many lines may be accounted for by all the possible electron transitions between the three lowest principle quantum levels?

A 1   **B** 2   **C** 3   **D** 4   **E** 5

A12 A serious structural engineering issue is that of radioactive waste storage, due to high emission levels and extremely long decay times. Uranium-238 decays via alpha emission with a half-life of 4.5 x 10^9 yr. How long will it take for the activity of a uranium-238 sample to be reduced to a quarter of its original value?

A 1.1 x 10^9 yr   **B** 2.2 x 10^9 yr   **C** 4.5 x 10^9 yr   **D** 9.0 x 10^9 yr   **E** 1.8 x 10^{10} yr

A13 Chemical engineering of the fractional distillation process, that yields raw materials for the petrochemical industry, is underpinned by the behaviour of liquid mixtures. Which of the following characteristics is **UNTRUE** of a binary liquid mixture showing negligible deviation from Raoult's law?

A The total vapour pressure over the mixture is equal to that expected for an ideal mixture.

B Mixing the two liquids results in no change in temperature.

C The forces between the molecules of the two components are similar to the forces between the molecules within each pure component.

D Fractional distillation of such a mixture will yield a distillate richer in the lower boiling component.

E The boiling point-composition diagram of such a mixture will be a straight line.

A14 For which of the following elements is the first ionisation energy greater than the second?

  A Na   **B** C   **C** N   **D** O   **E** None of these

A15 Si is an element that behaves as a semi-conductor. It has therefore found widespread use in the electronics industry. The electronic ground state configuration of Si is?

  A [Ne] $3s^2 3p^2$.
  B [He] $2s^2 2p^2$.
  C [Ne] $3s^2 3p^4$.
  D [He] $2s^2 2p^4$.
  E [Ar] $3s^2 3p^2$.

A16 Aromatic rings are most susceptible to attack via:

  A Electrophilic substitution.
  B Nucleophilic substitution.
  C Electrophilic addition.
  D Nucleophilic addition.
  E Condensation reactions.

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 acetylene.

C octane.

D pent-2-yne.

E cyclohexene.

A19 Which of the following may be oxidised to a carboxylic acid

A propan-1-ol.

B propan-2-ol.

C propene.

D propanone.

E propyne.

A20 Control of optical isomerism is critical in biomolecular engineering. Which of the following molecules exhibits optical isomerism?

A. 1-fluorobutane

B. 2-fluorobutane

C. 1-fluoropentane

D. 3-fluoropentane

E. cyclopentane

A21 The oxidation state of chromium in dichromate $Cr_2O_7^{2-}$ is

| A 3 | B 4 | C 5 | D 6 | E 7 |

A22 The initial rate of the reaction $NO(g) + Cl_2(g) \rightarrow NOCl(g) + Cl (g)$ is

A indeterminable without experimental data

B $k[NO(g)][Cl_2(g)]$

C k

D $k[NOCl(g)][Cl(g)]$

E $k[NOCl(g)]^{-1}[Cl(g)]^{-1}$

A23 Covalent bonds range in strength from:

A $10 - 50$ kJ mol^{-1}

B $50 - 100$ kJ mol^{-1}

C $100 - 900$ kJ mol^{-1}

D $900 - 1300$ kJ mol^{-1}

E $1300 - 1600$ kJ mol^{-1}

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   There are FIVE main factors that influence reaction rate. List all five and explain VERY
      BRIEFLY why each one affects reaction rate.   **10 marks**

B2   Briefly state what you understand by the terms , homologous series, condensation reaction,
      termination step, enthalpy change and van der Waal's forces.

                                                                                      10 marks

B3   a) Explain the meaning of the terms S_N1 and S_N2 as applied to reaction mechanisms.

                                                                                       2 marks

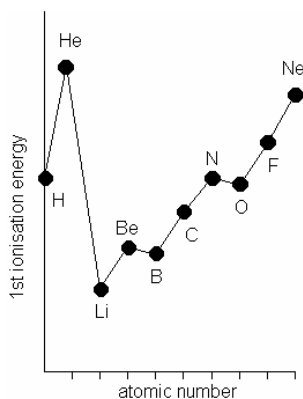   b) Briefly detail the differences between the two in terms of

         i) molecularity   **2 marks**
         ii) control of optical isomerism   **4 marks**
      c) Give ONE method of preferentially promoting either mechanism   **2 marks**

B4   The image below shows trends in 1st ionisation energy of the elements across the first two
      periods. Explain these trends.   **10 marks**

Section C   Answer ONLY ONE question

C1   An alcohol **A** $C_4H_{10}O$ reacts with concentrated sulphuric acid to yield two isomeric compounds **B** and **C** C_4H_8. Ozonolysis of **B** yields only **D** C_2H_4O. Ozonolysis of **C** yields **E** and **F** CH_2O. Treatment of **A** with acidified potassium dichromate yields **G** C_4H_8O.
Give the names AND structures for compounds **A** – **G**. You will gain very little credit unless you FULLY explain your reasoning.   **35 marks**

C2   a) Explain the term resonance as applied to organic chemistry.   **4 marks**

b) Name the French scientist who proposed resonance forms for benzene thus leading to the idea of a delocalised electron cloud.   **2 marks**

c) Draw the resonance forms of benzene   **4 marks**

d) Explain in detail why phenol is a stronger acid than ethanol   **12 marks**

e) Draw all possible resonance forms of the ethanoate anion formed when ethanoic acid gives up a proton. How does resonance increase the acidity of ethanoic acid?   **7 marks**

f) Draw the possible resonance forms of ozone   **4 marks**

g) Based on these resonance forms draw an average structure for ozone.   **2 marks**

C3   a) With reference to vapour pressure/composition curves, boiling point/composition curves, Raoult's law and intermolecular forces, discuss the varying behaviour of binary liquid mixtures towards boiling.

        25 marks

b) With the use of appropriate diagrams explain the technique of distillation and highlight the limitations of this technique with respect to certain liquid mixtures.

        10 marks