MODULE EXAMINATION

CH1001: FOUNDATION CHEMISTRY

January 2007 **Time available: 2 hours**

Answer any FIVE questions: all questions carry equal weight

1. Attempt **ALL** parts

(a) Give the electronic configurations for the following atoms and ions:

Li, S^{2-}, P, Ga, B

[10 marks]

(b) What quantum numbers are associated with the following orbitals?

1s, 3p, 4f, 3s

[8 marks]

(c) Sketch all three 2p orbitals.

[2 marks]

2. Attempt **ALL** parts

(a) Draw and describe the structure of white (elemental) phosphorus.

[5 marks]

(b) (i) Write/

2. (continued)

(b) (i) Write a balanced equation for the oxidation of white phosphorus in a limited supply of oxygen to form product **A**.

[3 marks]

(ii) Draw and describe the structure of the product **A**.

[3 marks]

(iii) What is the oxidation state of phosphorus in product **A**?

[1 mark]

(c) (i) Write a balanced equation for the oxidation of white phosphorus in excess oxygen to form product **B**.

[3 marks]

(ii) What is the oxidation state of phosphorus in this product **B**?

[1 mark]

(d) Products **A** and **B** are both acidic oxides. Write balanced equations for their reaction with water (requires two equations, one for reaction of **A** with water and one for reaction of **B** with water.)

[4 marks]

3. Attempt **ALL** parts

(a) Consider the vaporisation of mercury,

$$Hg(1) \rightleftharpoons Hg(g)$$

The following table of thermodynamic quantities are measured at 298 K.

	ΔH_f^{θ}/kJmol^{-1}	S^{θ}/ JK^{-1}mol^{-1}
Hg (l)	0	76.02
Hg (g)	+61.32	174.96

(i) Calculate, the standard enthalpy of vaporisation, ΔH_{vap}^{θ}, at 298 K.

[2 marks]

(ii) Calculate the standard entropy of vaporisation, ΔS_{vap}^{θ}, at 298 K.

[2 marks]

(iii) Calculate/

3. (continued)

(iii) Calculate the standard Gibbs free energy of vaporisation, ΔG_{vap}^{θ}, at 298 K.

[2 marks]

(iv) Calculate the equilibrium constant at 298 K.

[2 marks]

(v) What is the vapour pressure of Hg(l) at 298 K?

[2 marks]

(vi) Trouton's rule states that the standard molar entropy of vaporisation is approximately 85 $JK^{-1}mol^{-1}$ for the vaporisation of any liquid at its boiling point. At the boiling point of mercury (630 K), ΔS_{vap}^{θ} is 93.55 $JK^{-1}mol^{-1}$. Explain why this value is higher than that predicted by Trouton's rule.

[3 marks]

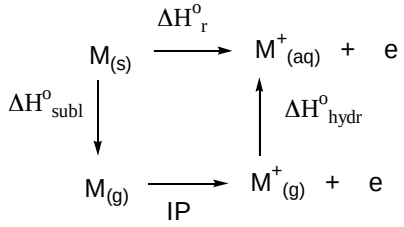
(b) A radioactive isotope undergoes first order decay with a half-life of 22 years. If 1g of the isotope is released into the environment, calculate the amount that will remain after 100 years.

[7 marks]

4. Attempt **ALL** parts

(a) Discuss the thermochemical cycle below and use it to explain why the order of thermodynamic reactivity for the Group 1 metals with water is:

Li > K ~ Rb > Cs > Na



[5 marks]

(b) Explain/

4. (continued)

(b) Explain why when solid LiCl dissolves in water the temperature of the solution increases sharply before reaching thermodynamic equilibrium with the surroundings whereas when solid KCl dissolves the solution temperature drops before reaching equilibrium.

[4 marks]

(c) (i) Starting from siderite ore ($FeCO_3$) describe the various steps involved in the extraction of iron using the Blast Furnace process.

[5 marks]

(ii) The Blast Furnace operates at temperatures in excess of 700 °C. Why is this important?

[2 marks]

(iii) Explain why it would be desirable to use titanium in place of iron for many applications but this has not so far proved possible.

[4 marks]

5. Attempt **ALL** parts

(a) Discuss Raoult's Law. Include in your discussion issues such as positive and negative deviations from Raoult's Law.

[7 marks]

(b) A 0.5 L flask is evacuated and then weighed. It is then filled with a gas at a pressure of 1520 mm Hg (760 mm Hg = 1.013×10^5 Pa) at 27 °C.

(i) How many moles of gas are present?

(ii) If the flask now weighs an extra 1.15 g, suggest which gas it could be.

[7 marks]

(c) In real gases, the compression factor Z does not always equal 1. On a plot of Z against pressure, sketch the Z vs P behaviour for nitrogen (N_2) at different temperatures.

Explain this behaviour.

[6 marks]

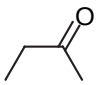
6. Attempt/

6. Attempt **ALL** parts

(a) Determine the molecular formula of a compound containing carbon, hydrogen and oxygen. The elemental composition is C, 74.99 %; H, 5.03 %; and the molecular ion in the mass spectrum is at 160.05.

[5 marks]

(b) An unknown compound has the molecular formula C_4H_8O. The IR spectrum features a strong absorption band at 1718 cm^{-1}. The UV spectrum shows a single absorption band at 270 nm. Which of the following structures match with the data provided?

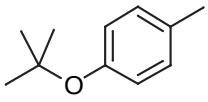


A

B

[5 marks]

(c) Predict the ^1H NMR spectrum of 4-*tert*-butoxytoluene. Number of signals, relative integral intensities and multiplicities are required.

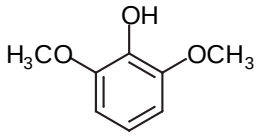


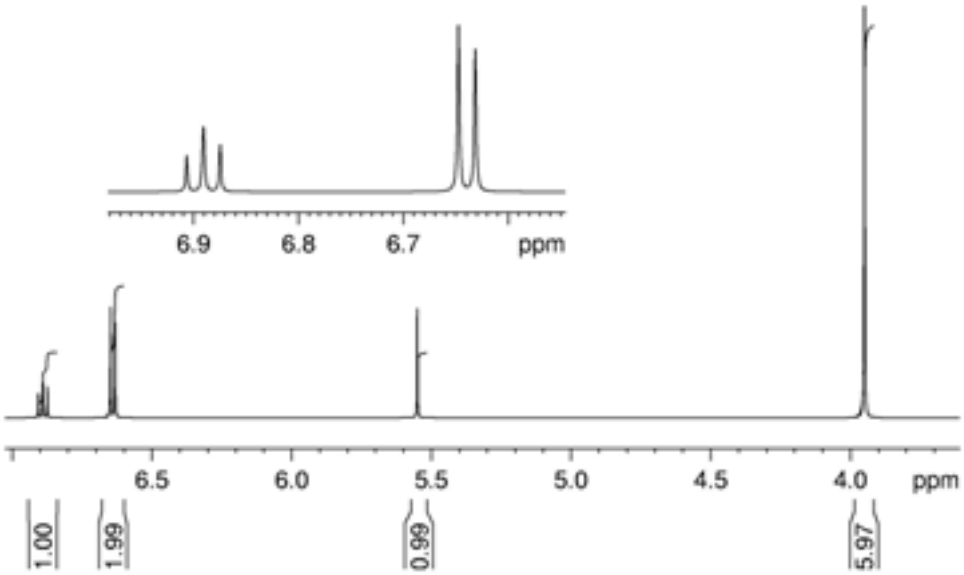
[5 marks]

(d) Assign/

6. (continued)

(d) Assign all resonances in the ^{1}H NMR spectrum of 2,6-dimethoxyphenol.





[5 marks]