

NAME:
STUDENT ID N^o

CHEM 114: Mid-course TEST
THURSDAY 5th MAY 2005 7.00-9.00pm
Answer ALL QUESTIONS

TIME MANAGEMENT:

This examination is marked out of 120. An approximate marking scheme is provided to help you allocate your time effectively. You are encouraged to spend approximately 1 minute per mark allocated.

ANSWERS:

Fill in your answers in the spaces provided. If you need more space (e.g. for calculation workings) please use the blank paper on the back of the preceding page

PERIODIC TABLE:

A Periodic Table is included on a separate sheet. You are encouraged to use it.

QUESTION 1**[17 marks total]**

Magnesium (Mg) and aluminium (Al) each react with fluorine (F₂) to produce fluoride salts

- (a) Write out the electronic configurations for each of these three elements [6 marks]

Al F Mg

- (b) Write out balanced equations for the formation of magnesium fluoride and aluminium fluoride from the respective elements. [6 marks]
- (c) If 5 g of aluminium reacts completely with fluorine, how many grams of aluminium fluoride are produced? [5 marks]

QUESTION 2**[18 marks total]**

There are several different kinds of forces of attraction associated with molecules. The magnitude of these forces have important effects on the physical properties of molecular compounds.

- (a) For the following parts, (i) – (iii), circle the correct answer [3 marks]

- (i) Hydrogen bonds are stronger than:

van der Waals forces covalent bonds ionic bonds

- (ii) Attractive forces between non-polar molecules are due to interactions between:

permanent dipoles temporary dipoles ions

- (iii) Boiling a molecular compound involves breaking:

intramolecular attractions intermolecular attractions

The following table gives the boiling points of five organic molecules. Answer questions (b)-(d) using these data.

TABLE: Boiling points of some organic compounds

Compound	Formula	Relative molecular mass	Boiling point (°C)
Pentane	CH ₃ (CH ₂) ₃ CH ₃	72	35
Dimethylpentane	CH ₃ CH ₂ (CHCH ₃)CH(CH ₃) ₂	100	89
Heptane	CH ₃ (CH ₂) ₅ CH ₃	100	98
Hexanol	CH ₃ (CH ₂) ₅ OH	102	156
Pentanediol	HO(CH ₂) ₅ OH	104	242

- (b) The only significant intermolecular forces of attraction of some molecules in the table are due to temporary dipoles. Identify these molecules and explain your choice. [5 marks]
- (c) Using specific information about the molecules you identify in part (b), explain how molecular size and shape affect the magnitude of intermolecular forces in non-polar molecular compounds. [5 marks]
- (d) Using specific information from the table, explain the effect of changing CH₃ groups to OH groups on the boiling point of organic molecules. Why do hydroxyl groups have this effect? [5 marks]

QUESTION 3

[33 marks total]

Potassium chloride is a white crystalline material which is soluble in water.

- (a) Use a description of the bonding in potassium chloride to explain why it is a brittle, crystalline solid with a high melting point. [6 marks]
- (b) Crystals of potassium chloride do not conduct electricity, but molten (liquid) potassium chloride is an electrical conductor. Why? [3 marks]

The following table provides values for enthalpy changes which are related to the aqueous solubility of potassium chloride. Use this information to answer parts (c) – (g).

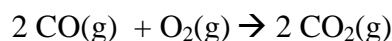
TABLE

(i) Hydration of potassium ions	$\text{K}^+(\text{g}) \rightarrow \text{K}^+(\text{aq}), \Delta H_{\text{hyd}} = -320 \text{ kJ mol}^{-1}$
(ii) Hydration of chloride ions	$\text{Cl}^-(\text{g}) \rightarrow \text{Cl}^-(\text{aq}), \Delta H_{\text{hyd}} = -364 \text{ kJ mol}^{-1}$
(iii) Potassium chloride lattice formation	$\text{K}^+(\text{g}) + \text{Cl}^-(\text{g}), \rightarrow \text{KCl}(\text{s}), \Delta H = -720 \text{ kJ mol}^{-1}$

- (c) For each of the three processes, (i) – (iii), listed in the **TABLE** briefly explain the reasons for the value (the sign and the magnitude) of the enthalpy change. [9 marks]
- (d) Use the values given in the **TABLE** to calculate the overall enthalpy change which occurs when potassium chloride dissolves in water. Briefly explain your reasoning. [5 marks]
- (e) When potassium chloride is dissolved in water, does the temperature of the water increase or decrease? Briefly explain your reasoning. In your answer, specify whether the overall process is endothermic, or exothermic. [3 marks]
- (f) Do you expect the entropy change for the solvation of potassium chloride in water to be negative or positive? Briefly explain your reasoning. [3 marks]
- (g) Does potassium chloride dissolve in water because of a favourable enthalpy of solvation or because of a favourable entropy of solvation, or both? Briefly explain your reasoning. [4 marks]

QUESTION 4**[30 marks total]**

In the final stages of combustion in a fire, carbon monoxide is oxidized by oxygen to produce carbon dioxide according to the following equation.

**Part I**

- (a) A 1 litre sample of pure carbon monoxide at 25°C (298K) has a mass of 1.145 g. What mass of oxygen would be required to react exactly with this amount of carbon monoxide? [5 marks]
- (b) What is the volume of pure oxygen needed for the reaction in part (a)? [2 marks]

Part II

The reaction of carbon monoxide with oxygen was carried out at a range of concentrations of the reactants and the rate of reaction was determined under each reaction condition. Some of these rate data are presented in the following **TABLE**.

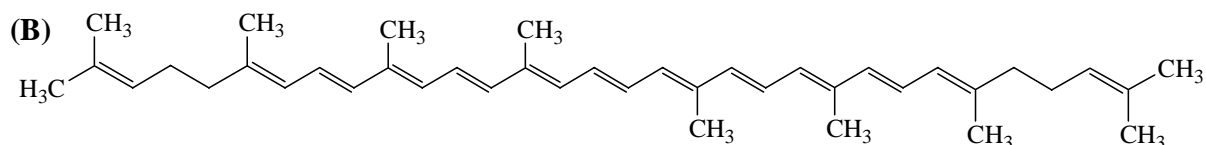
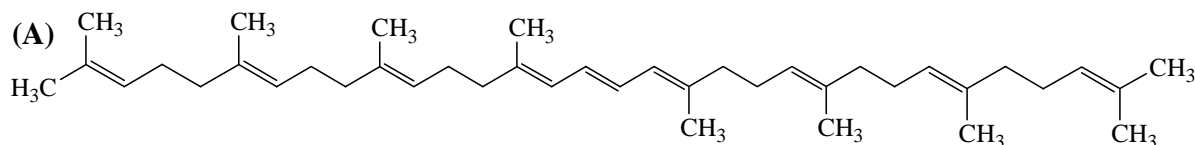
TABLE

Experiment	[CO] (M)	[O ₂] (M)	Rate of reaction (mol L ⁻¹ min ⁻¹)
1	0.02	0.02	3.68 x 10 ⁻⁵
2	0.04	0.02	1.47 x 10 ⁻⁴
3	0.02	0.04	7.36 x 10 ⁻⁵

- (c) Is this reaction zero order, first order or second order with respect to carbon monoxide? Briefly explain your reasoning. [4 marks]
- (d) Is this reaction zero order, first order or second order with respect oxygen? Briefly explain your reasoning. [4 marks]
- (e) A small amount of oxygen was added to a flask full of carbon monoxide. After 9 seconds the amount of oxygen had decreased from 8 x 10⁻⁶ mol to 4 x 10⁻⁶ mol. How much longer would it take for the amount of oxygen to decrease to 1 x 10⁻⁶ mol? Briefly explain your reasoning. [4 marks]
- (f) In the oxidation of carbon monoxide in part (e), which of the following plots would give a straight-line graph for the change on oxygen concentration ([O₂]) with time (t):
[O₂] vs t;
ln[O₂] vs t;
or 1/[O₂] vs t?
Briefly explain your reasoning. [4 marks]
- (g) Write out a rate equation for this reaction (*i.e.* an expression linking the rate of reaction with the concentrations of carbon monoxide and oxygen and the rate constant, *k*, for the reaction). [3 marks]
- (h) Calculate the rate constant, *k*, for the reaction. [4 marks]

QUESTION 5**[4 marks total]**

The red colour of tomato plants is due to absorption of visible light by an organic molecule, lycopene. This molecule is made in the plant from a similar, but colourless, molecule phytoene. The structures of these two molecules are given below. Identify whether (A) or (B) is lycopene. Briefly explain your reasoning. [4 marks]

**QUESTION 6****[18 marks total]**

Nitrogen (N_2) and hydrogen (H_2) react to form ammonia (NH_3) in an equilibrium process.

- (a) Write a balanced equation for this reaction. [3 marks]
- (b) Write an expression for the equilibrium constant, K , for this process in terms of the concentrations of hydrogen, $[H_2]$, nitrogen, $[N_2]$ and ammonia, $[NH_3]$. [3 marks]
- (c) This reaction is carried out industrially to make ammonia. In the industrial process the reaction is carried out at high pressure. Briefly explain the reason(s) for doing this. [4 marks]
- (d) The enthalpy change for this process $\Delta H = -111 \text{ kJ mol}^{-1}$ under the industrial conditions. Is the reaction endothermic or exothermic? [2 marks]
- (e) Is the equilibrium more, or less, favourable for production of ammonia at high temperatures. Briefly explain your reasoning. [3 marks]
- (f) Why is the industrial reaction carried out at high temperatures (450°C)? Briefly explain your reasoning. [3 marks]

END OF TEST