**Name: Out of 56**

**A2 Equilibria – Test**

**1.** Acid **X** reacts with methanol to form ester **Y** according to the following equation.



A mixture of 0.25 mol of **X** and 0.34 mol of methanol was left to reach equilibrium in the presence of a small amount of concentrated sulphuric acid. The equilibrium mixture thus formed contained 0.13 mol of **Y** in a total volume of *V* dm3.

(a) Name **X**.

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(1)

(b) Using **X** to represent the acid and **Y** to represent the ester, write an expression for the equilibrium constant, *K*c, for this reaction.

(1)

(c) Calculate the number of moles of **X**, the number of moles of methanol and the number of moles of water in the equilibrium mixture.

*Moles of* **X** ..............................................................................................................

*Moles of methanol* ...................................................................................................

*Moles of water* .........................................................................................................

(3)

(d) State why the volume *V* need not be known in calculating the value of *K*c for the reaction.

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(1)

(e) Calculate the value of *K*c for this reaction and deduce its units.

*Calculation* .............................................................................................................

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*Units of K*c ..............................................................................................................

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(3)

(f) State the effect, if any, of increasing the temperature on the value of *K*c

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(1)

(Total 10 marks)

**2.** Nitrogen dioxide dissociates according to the following equation.

2NO2(g)  2NO(g) + O2(g)

When 21.3 g of nitrogen dioxide were heated to a constant temperature, *T*, in a flask of volume 11.5 dm3, an equilibrium mixture was formed which contained 7.04 g of oxygen.

(a) (i) Calculate the number of moles of oxygen present in this equilibrium mixture and deduce the number of moles of nitrogen monoxide also present in this equilibrium mixture.

*Number of moles Of O2 at equilibrium* ........................................................

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*Number of moles of NO at equilibrium* .......................................................

(ii) Calculate the number of moles in the original 21.3 g of nitrogen dioxide and hence calculate the number of moles of nitrogen dioxide present in this equilibrium mixture.

*Original number of moles of NO2* ................................................................

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*Number of moles of NO2 at equilibrium* ......................................................

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(4)

(b) Write an expression for the equilibrium constant, *K*c, for this reaction. Calculate the value of this constant at temperature T and give its units.

*Expression for Kc* ...................................................................................................

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*Calculation* ............................................................................................................

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(4)

(c) The total number of moles of gas in the flask is 0.683. Use the ideal gas equation to determine the temperature *T* at which the total pressure in the flask is 3.30 × 105 Pa.   
(The gas constant *R* = 8.31 J K–1mol–1)

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(3)

(d) State the effect on the equilibrium yield of oxygen and on the value of Kc when the same mass of nitrogen dioxide is heated to the same temperature *T*, but in a different flask of greater volume.

*Yield of oxygen* ......................................................................................................

*Value of Kc* .............................................................................................................

(2)

(Total 13 marks)

**3.** Tetrafluoroethene, C2F4, is obtained from chlorodifluoromethane, CHClF2, according to the equation:

2CHClF2(g)  C2F4(g) + 2HCl(g) 

(a) A 1.0 mol sample of CHClF2 is placed in a container of volume 18.5 dm3 and heated.

When equilibrium is reached, the mixture contains 0.20 mol of CHClF2

(i) Calculate the number of moles of C2F4 and the number of moles of HCl present at equilibrium.

*Number of moles of C2F4* ...................................................................

*Number of moles of HCl* .....................................................................

(ii) Write an expression for *K*c for the equilibrium.

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(iii) Calculate a value for *K*c and give its units.

*Calculation* ......................................................................................................

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*Units* .................................................................................................................

(6)

(b) (i) State how the temperature should be changed at constant pressure to increase the equilibrium yield of C2F4

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(ii) State how the total pressure should be changed at constant temperature to increase the equilibrium yield of C2F4

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(2)

(Total 8 marks)

**4.** (a) The expression for an equilibrium constant, *K*c, for a homogeneous equilibrium reaction is given below.



(i) Write an equation for the forward reaction.

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(ii) Deduce the units of *K*c

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(iii) State what can be deduced from the fact that the value of *K*c is larger when the equilibrium is established at a lower temperature.

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(3)

(b) A 36.8 g sample of N2O4 was heated in a closed flask of volume 16.0 dm3. An equilibrium was established at a constant temperature according to the following equation.

N2O4(g)  2NO2(g)

The equilibrium mixture was found to contain 0.180 mol of N2O4

(i) Calculate the number of moles of N2O4 in the 36.8 g sample.

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(ii) Calculate the number of moles of NO2 in the equilibrium mixture.

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(iii) Write an expression for *K*c and calculate its value under these conditions.

*Expression for Kc* .............................................................................................

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*Calculation* ......................................................................................................

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(iv) Another 36.8 g sample of N2O4 was heated to the same temperature as in the original experiment, but in a larger flask. State the effect, if any, of this change on the position of equilibrium and on the value of *K*c compared with the original experiment.

*Effect on the position of equilibrium* ...............................................................

*Effect on the value of K*c ...................................................................................

(9)

(Total 12 marks)

**Section B**

**5.** (a) A flask containing a mixture of 0.200 mol of ethanoic acid and 0.110 mol of ethanol was maintained at 25 °C until the following equilibrium had been established.

CH3COOH(l) + C2H5OH(l)  CH3COOC2H5(l) + H2O(l)

The ethanoic acid present at equilibrium required 72.5 cm3 of a 1.50 mol dm–3 solution of sodium hydroxide for complete reaction.

(i) Calculate the value of the equilibrium constant, *K*c, for this reaction at 25 °C.

(ii) The enthalpy change for this reaction is quite small. By reference to the number and type of bonds broken and made, explain how this might have been predicted.

(9)

(b) Aspirin can be prepared by acylation using either ethanoyl chloride or ethanoic anhydride, as represented by the equations shown below.

CH3COCl + HOC6H4COOH  CH3COOC6H4COOH + HCl

(CH3CO)2O + HOC6H4COOH  CH3COOC6H4COOH + CH3COOH

(i) By a consideration of the intermolecular forces involved, explain why the product HCl is a gas but the product CH3COOH is a liquid at room temperature.

(ii) Give **two** industrial advantages of using ethanoic anhydride rather than ethanoyl chloride in the manufacture of aspirin.

(4)

(Total 13 marks)