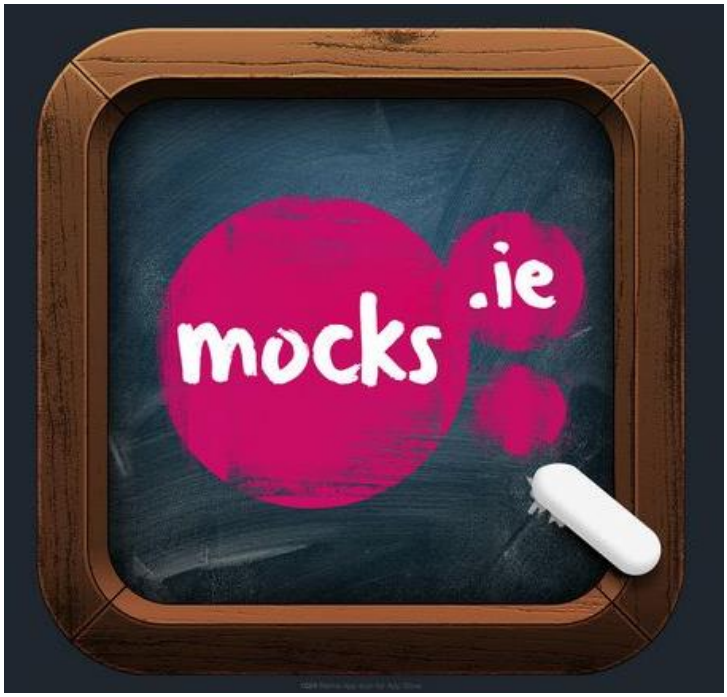

Chemical Equilibrium

Chemistry Past Exam Questions

Higher Level

2013

Section B - Question 9

9. (*a*) What is meant by *chemical equilibrium*? Why is a chemical equilibrium described as *dynamic*? (8)

State *Le Châtelier's principle*. (6)

(*b*) When a yellow solution of iron(III) chloride ($FeCl_3$) and a colourless solution of potassium thiocyanate (**KCNS**) were mixed in a test tube, a red colour appeared and the following equilibrium was established:

$$\underset{\text{yellow}}{Fe^{3+}_{(aq)}} + CNS^-_{(aq)} \rightleftharpoons \underset{\text{red}}{Fe(CNS)^{2+}_{(aq)}}$$

Explain

(*i*) the effect on the Fe^{3+} ion concentration of adding **KCNS** to the equilibrium mixture,

(*ii*) why changing the pressure has no effect on this equilibrium. (9)

(*c*) Write the equilibrium constant (K_c) expression for this reaction. (6)

A mixture of 1.0×10^{-3} moles each of iron(III) chloride and potassium thiocyanate was allowed to come to equilibrium in 1 litre of solution at room temperature according to the equation above. It was found that 1.1×10^{-4} moles $Fe(CNS)^{2+}$ were present in the solution at equilibrium.

Calculate the value of the equilibrium constant (K_c) for the reaction. (12)

(*d*) The red colour faded when the test tube containing the equilibrium mixture was placed in an ice-water bath.

State whether the value of K_c for this reaction is bigger or smaller at the lower temperature.

Is the forward reaction exothermic *or* endothermic? Justify your answer. (9)

2012

Section B - Question 11 B

(*b*) Consider the following room temperature equilibrium reaction used to dissolve iodine (I_2) crystals in an aqueous solution of iodide ions (I^-).

$$I_{2\,(aq)} + I^-_{(aq)} \rightleftharpoons I_3^-{}_{(aq)}$$

When 0.0800 moles of iodine crystals and 0.2400 moles of iodide ions were added to deionised water and made up to a litre of solution, 0.0793 moles of triiodide ions (I_3^-) were present at equilibrium.

Write the equilibrium constant (K_c) expression for this equilibrium reaction. (6)

Calculate the value of the equilibrium constant (K_c) for the reaction at room temperature. (12)

State and explain the effect on the equilibrium concentration of triiodide ions of adding a substance that reacts with iodine, e.g. starch. (7)

2009

Section B - Question 11 A

11. Answer any **two** of the parts (*a*), (*b*) and (*c*). (2 × 25)

(*a*) Ammonia is formed in the Haber process according to the following balanced equation.

$$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

The table shows the percentages of ammonia present at equilibrium under different conditions of temperature T and pressure P when hydrogen and nitrogen gases were mixed in a 3:1 molar ratio.

P/atm \ *T*/K	573	673	773
10	15	4	1
100	51	25	10
200	63	36	18
1000	92	80	58

(*i*) Find from the table the conditions of temperature and pressure at which the highest yield of ammonia is obtained. (4)

(*ii*) Deduce from the data whether this reaction is exothermic or endothermic. Explain your reasoning. (6)

(*iii*) Identify **one** industrial problem associated with the use of high pressures. (3)

(*iv*) Write an equilibrium constant (K_c) expression for this reaction. (6)

(*v*) State the effect on the value of K_c of using a catalyst. Justify your answer. (6)

2008

Section B - Question 7

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7. A chemical equilibrium is established when eleven moles of hydrogen and eleven moles of iodine are mixed at a temperature of 764 K. Initially the colour of the mixture is deep purple due to the high concentration of iodine vapour. The purple colour fades and when equilibrium is established the colour of the mixture is pale pink and there are seventeen moles of hydrogen iodide present.

The equilibrium is represented by the equation

$$\underset{\text{colourless}}{H_{2\,(g)}} + \underset{\text{purple}}{I_{2\,(g)}} \rightleftharpoons \underset{\text{colourless}}{2HI_{(g)}} \qquad \Delta H = 51.8\ \text{kJ}$$

(*a*) What is meant by *chemical equilibrium*?

When the colour of the mixture has become pale pink, has reaction ceased? Explain. (11)

(*b*) Write an expression for the equilibrium constant (K_c) for the reaction. (6)

Calculate the value of the equilibrium constant (K_c) at 764 K. (12)

(*c*) State *Le Châtelier's principle*. (6)

Use Le Châtelier's principle to predict and explain the effect of a decrease in temperature on

(*i*) the yield of hydrogen iodide, (*ii*) the intensity of colour of the equilibrium mixture. (9)

What change, if any, will an increase in the pressure on the equilibrium mixture have on the yield of hydrogen iodide? Explain. (6)

2007

Section B - Question 10 A

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10. Answer any **two** of the parts (*a*), (*b*) and (*c*). (2 × 25)

(*a*) (*i*) Write the equilibrium constant (K_c) expression for the reaction (7)

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

(*ii*) Three moles of nitrogen gas and nine moles of hydrogen gas were mixed in a 1 litre vessel at a temperature *T*. There were two moles of ammonia in the vessel at equilibrium. Calculate the value of K_c for this reaction at this temperature. (12)

(*iii*) Henri Le Chatelier, pictured on the right, studied equilibrium reactions in industry in the late 19th century. According to Le Chatelier's principle, what effect would an increase in pressure have on the yield of ammonia at equilibrium? Explain. (6)

2006

Section B - Question 11 B

(*b*) State *Le Châtelier's principle.* (7)

The following equilibrium is set up in solution by dissolving cobalt(II) chloride crystals in water to form the pink species $Co(H_2O)_6^{2+}$ and then adding concentrated hydrochloric acid until the solution becomes blue.

$$\underset{\text{pink}}{Co(H_2O)_6^{2+}} + 4Cl^- \rightleftharpoons \underset{\text{blue}}{CoCl_4^{2-}} + 6H_2O$$

(*i*) When the solution becomes blue, has reaction ceased? Explain. (6)

(*ii*) The forward reaction is endothermic. State and explain the colour change observed on cooling the reaction mixture. (6)

(*iii*) Other than heating, mention **one** way of reversing the change caused by cooling the reaction mixture. (6)

2005

Section B - Question 9

9. (*a*) State *Le Chatelier's principle*. (5)

(*b*) A student is provided with glassware and other laboratory apparatus as well as the following chemicals: potassium dichromate(VI) ($K_2Cr_2O_7.2H_2O$), hydrochloric acid ($HCl_{(aq)}$), sodium hydroxide ($NaOH$), cobalt(II) chloride crystals ($CoCl_2.6H_2O$) and deionised water (H_2O).

(*i*) Describe clearly how the student could use a selection of the chemicals listed above to establish a chemical equilibrium. Write a balanced equation for the equilibrium. (12)

(*ii*) Describe how the student could then demonstrate the effect of concentration on that chemical equilibrium. State the observations made during the demonstration. (9)

(*c*) The value of K_c for the following equilibrium reaction is 4.0 at a temperature of 373 K.

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

(*i*) Write the equilibrium constant (K_c) expression for this reaction. (6)

(*ii*) What mass of ethyl ethanoate ($CH_3COOC_2H_5$) would be present in the equilibrium mixture if 15 g of ethanoic acid and 11.5 g of ethanol were mixed and equilibrium was established at this temperature? (18)