Chemical Equilibria

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Application of Core Principles of Chemistry
Sub Topic	Chemical Equilibria
Booklet	Question Paper

Time Allowed:

30 minutes

Score: /25

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 An aqueous solution contains dichromate(VI) ions, $Cr_2O_7^{2-}$, and chromate(VI) ions, CrO_4^{2-}, in equilibrium. This solution is a pale orange colour.

$$Cr_2O_7^{2-}(aq) + H_2O(l) \rightleftharpoons 2CrO_4^{2-}(aq) + 2H^+(aq)$$
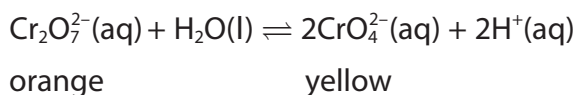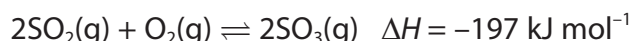
   orange   yellow

What would be seen when a few drops of concentrated sodium hydroxide solution are added to the equilibrium mixture?

   ☒ **A** No visible change.

   ☒ **B** The mixture turns green.

   ☒ **C** The mixture turns a deeper orange.

   ☒ **D** The mixture turns yellow.

(Total for Question 1 = 1 mark)

2 The following system was allowed to reach equilibrium at 450 °C.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -197 \text{ kJ mol}^{-1}$$

How would a decrease in pressure and an increase in temperature affect the equilibrium position?

	Shift in equilibrium position with a decrease in pressure	Shift in equilibrium position with an increase in temperature
☒ **A**	left	left
☒ **B**	left	right
☒ **C**	right	left
☒ **D**	right	right

(Total for Question 2 = 1 mark)

3 The chlorate(I) ion, $ClO^-(aq)$, is formed when chlorine dissolves in water.

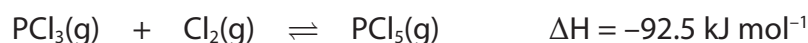$$Cl_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + Cl^-(aq) + ClO^-(aq)$$
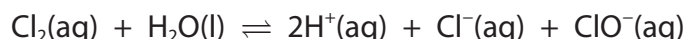
The concentration of chlorate(I) ions could be increased by the addition of

⊠ **A** solid potassium hydroxide.

⊠ **B** concentrated hydrochloric acid.

⊠ **C** solid sodium chloride.

⊠ **D** solid potassium sulfate.

(Total for Question 3 = 1 mark)

4 Consider the following equilibrium.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \qquad \Delta H = -92.5 \text{ kJ mol}^{-1}$$

In which of the following would **both** the stated changes increase the amount of the product, PCl_5, present at equilibrium?

⊠ **A** Decreasing temperature and decreasing pressure.

⊠ **B** Decreasing temperature and increasing pressure.

⊠ **C** Increasing temperature and increasing pressure.

⊠ **D** Increasing temperature and decreasing pressure.

(Total for Question 4 = 1 mark)

5 Consider the following simplified equilibrium for an indicator, HIn.

$$HIn(aq) \rightleftharpoons H^+(aq) + In^-(aq)$$
$$\text{yellow} \qquad\qquad\qquad \text{purple}$$
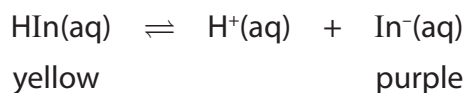
Addition of a few drops of sodium carbonate solution would

⊠ **A** make the colour of the equilibrium mixture turn purple and then yellow.

⊠ **B** make the colour of the equilibrium mixture paler.

⊠ **C** make the equilibrium mixture more yellow.

⊠ **D** make the equilibrium mixture more purple.

(Total for Question 5 = 1 mark)

6 The following equilibrium was established with all three substances present.

$$ICl(l) \quad + \quad Cl_2(g) \quad \rightleftharpoons \quad ICl_3(s)$$

brown   pale green   yellow

What would be the effect of increasing the pressure on this equilibrium system?

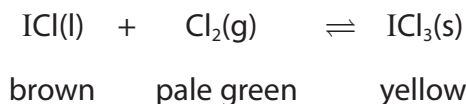☒ **A** No change.

☒ **B** An increase in the amount of the brown liquid.

☒ **C** An increase in the amounts of the brown liquid and the pale green gas.

☒ **D** An increase in the amount of the yellow solid.

(Total for Question 6 = 1 mark)

7 In the Contact Process for the production of sulfuric acid, there is a step in which sulfur dioxide is oxidized to sulfur trioxide as shown below.

$$2SO_2(g) \quad + \quad O_2(g) \quad \rightleftharpoons \quad 2SO_3(g) \quad \Delta H = -198 \text{ kJ mol}^{-1}$$

A high yield is obtained with the following conditions:

- 2 atm and 700 K

- 1:1 mole ratio of sulfur dioxide and oxygen

- catalyst vanadium(V) oxide, V_2O_5

In comparison with the conditions given above, which of the following would shift the equilibrium position to the right?

☒ **A** Lowering the pressure.

☒ **B** Increasing the temperature.

☒ **C** Increasing the excess of oxygen.

☒ **D** Using a more finely divided catalyst.

(Total for Question 7 = 1 mark)

8 Hydrogen and iodine gases were mixed at 300°C and allowed to reach equilibrium.

$$H_2(g) \quad + \quad I_2(g) \quad \rightleftharpoons \quad 2HI(g) \qquad \Delta H = -10 \text{ kJ mol}^{-1}$$
Colourless   Purple   Colourless
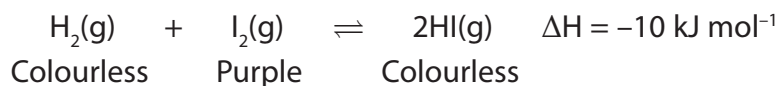
(a) What would you see if the equilibrium mixture was cooled to 250°C and equilibrium allowed to re-establish?

(1)

☒ **A** The mixture goes a darker purple.

☒ **B** The colour gets lighter.

☒ **C** The mixture goes colourless.

☒ **D** No visible change.

(b) The equilibrium mixture at 300°C was compressed in a gas syringe to occupy a smaller volume. What would be seen immediately after this compression?

(1)

☒ **A** The mixture goes a darker purple.

☒ **B** The colour gets lighter.

☒ **C** The mixture goes colourless.

☒ **D** No visible change.

(Total for Question 8 = 2 marks)

9 A concentrated solution of 'bromine water' is an orange colour. The following equilibrium exists in this solution.

$$Br_2(aq) \quad + \quad H_2O(l) \quad \rightleftharpoons \quad BrO^-(aq) \quad + \quad Br^-(aq) \quad + \quad 2H^+(aq)$$
Orange   Colourless
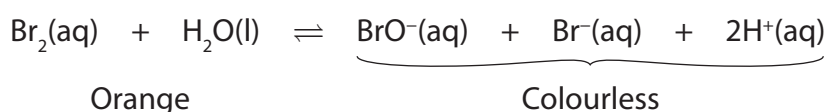
What would be the effect, if any, on the colour of the solution, if five drops of dilute sodium hydroxide solution were added to 5 cm³ of the bromine water?

☒ **A** The solution becomes a deeper orange.

☒ **B** The colour of the solution becomes lighter.

☒ **C** The solution goes colourless.

☒ **D** No visible change.

(Total for Question 9 = 1 mark)

10 Consider the following equilibrium.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$
Dark brown   Colourless
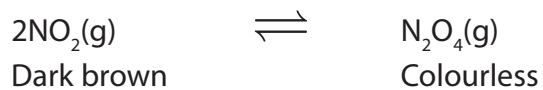
If the above equilibrium is initially set up so that the mixture is dark brown, then a gradual **decrease** in pressure would result in

☒ **A** no visible change.

☒ **B** a change to yellow.

☒ **C** a change to yellow then colourless.

☒ **D** a change to colourless.

(Total for Question 10 = 1 mark)

11 Poly(propenenitrile) is used in the manufacture of acrylic fibres for clothes.
Poly(propenenitrile) is an addition polymer made from propenenitrile.

The structure of propenenitrile is shown.

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\begin{array}{ccc}
H & & C\equiv N \\
 \diagdown & & \diagup \\
 & C = C & \\
 \diagup & & \diagdown \\
H & & H
\end{array}
$$
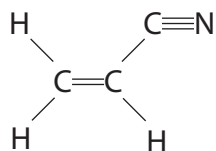
(a) Give a balanced equation, using displayed formulae, to show the formation of
poly(propenenitrile) from propenenitrile.

(3)

(b) Why does the reaction in (a) have an atom economy of 100%?

(1)

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*(c) Propenenitrile is manufactured from propene, C_3H_6, as shown in the following equation.

$$C_3H_6(g) + NH_3(g) + 1\tfrac{1}{2}O_2(g) \rightleftharpoons CH_2CHCN(g) + 3H_2O(g) \qquad \Delta H = -550 \text{ kJ mol}^{-1}$$

The process is carried out at a temperature of 450°C and a pressure of 2.5 atm, in the presence of a suitable catalyst.

State and explain the effect on the position of equilibrium when each of the following changes is made to these reaction conditions.

(i) The temperature is increased.

(2)

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(ii) The pressure is increased.

(2)

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*(d) Chemical manufacturers also use reaction conditions to control the rates of chemical reactions.

   (i) The curves in (d)(ii) and (d)(iii) show the distribution of molecular energies at a temperature, T_1.

   Label the axes on the diagrams in (d)(ii) and (d)(iii).

   (1)

   (ii) On the diagram below, draw a curve to show the distribution of molecular energies at a higher temperature, T_2.

   Use your diagram, with further labelling as necessary, to explain why the rate of a chemical reaction increases when the temperature is increased.

   (3)

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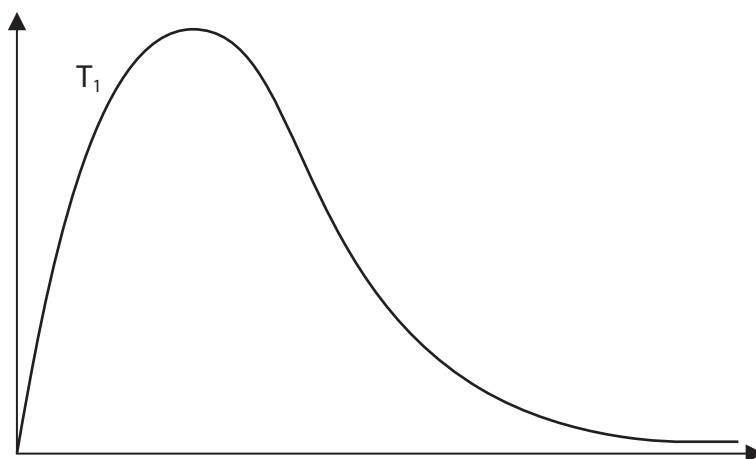
(iii) Use the diagram below, with further labelling as necessary, to explain why the rate of a chemical reaction increases when a catalyst is added at temperature T_1.

(2)

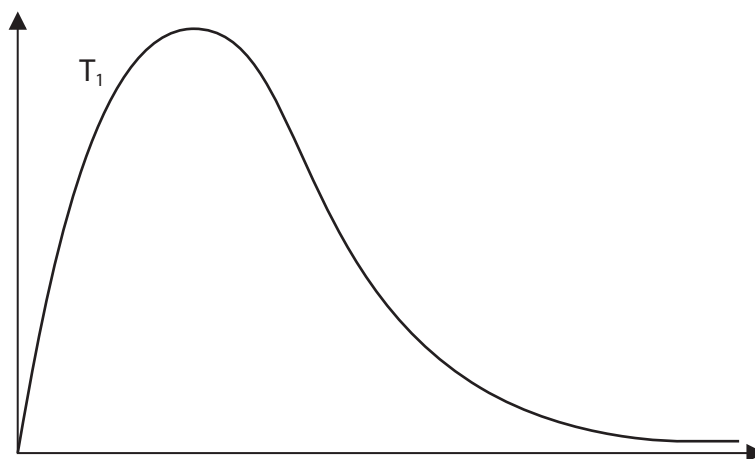...

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(Total for Question 11 = 14 marks)