Equilibria – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.13

In which equilibrium reaction is the position of equilibrium moved to the right-hand side by increasing the temperature and also by decreasing the pressure?

A $H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$ $\quad \Delta H = 40\,kJ\,mol^{-1}$

B $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\quad \Delta H = 58\,kJ\,mol^{-1}$

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

D $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ $\quad \Delta H = -10\,kJ\,mol^{-1}$

2. Nov/2022/Paper_11/No.14

Ethanol is produced industrially by reacting ethene and steam.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

K_p has a value of 1.8×10^{-5} and the partial pressures of the reactants at equilibrium are shown.

reactant	partial pressure / kPa
ethene	4.8×10^3
steam	2.8×10^3

Which row is correct?

	partial pressure of ethanol at equilibrium / kPa	units of K_p
A	2.42×10^2	kPa^{-1}
B	2.42×10^2	kPa
C	7.47×10^{11}	kPa^{-1}
D	7.47×10^{11}	kPa

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3. Nov/2022/Paper_12/No.7

Hydrogen peroxide decomposes slowly at 20 °C to form water and oxygen.

$$2H_2O_2 \rightleftharpoons 2H_2O + O_2 \qquad \text{equilibrium constant} = K_c$$

The reaction is faster when a catalyst is present.

Which statement is correct?

A The catalyst alters the Boltzmann distribution so that the reactant molecules have more energy.

B The catalyst has no effect on the value of K_c.

C The catalyst increases the value of K_c.

D The catalyst provides a different reaction mechanism with a higher activation energy.

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4. Nov/2022/Paper_12/No.8

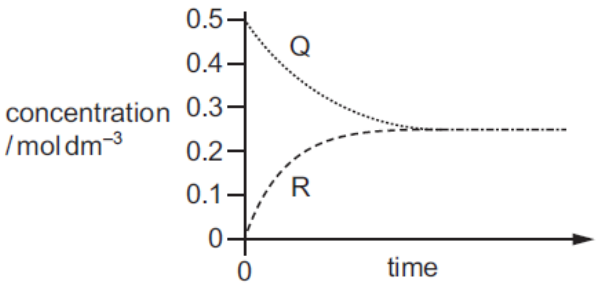
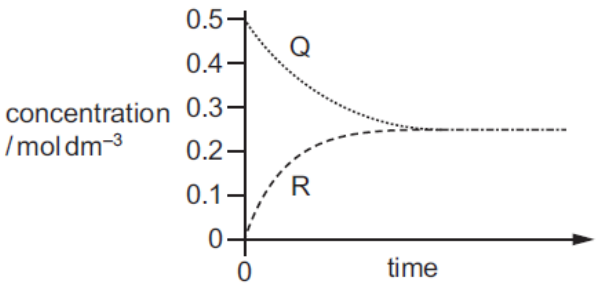
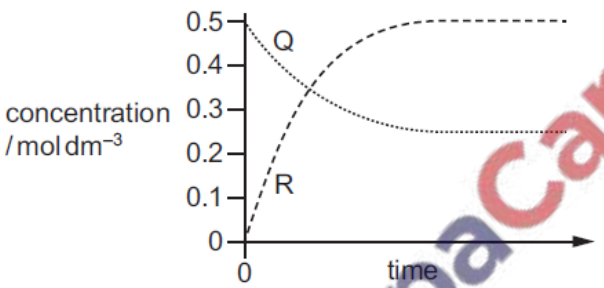
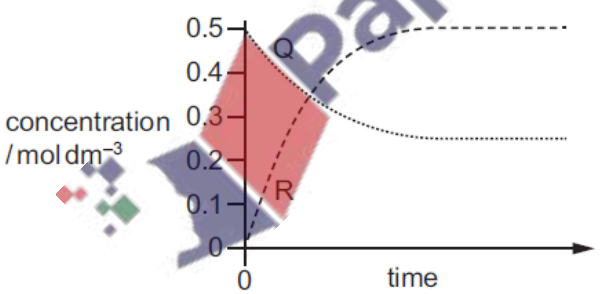
A dimer, Q, is stable when solid but a dynamic equilibrium is set up in solution.

$$Q(aq) \rightleftharpoons 2R(aq)$$

A solution of Q has an initial concentration of 0.50 mol dm^{-3}. When equilibrium has been reached, [Q(aq)] has fallen to 0.25 mol dm^{-3}.

The changes in [Q(aq)] and [R(aq)] are plotted against time until equilibrium is reached. The value of K_c is then calculated.

Which graph and value for K_c are correct?

	graph	K_c / mol dm^{-3}
A		1
B		0.25
C		1
D		2

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5. Nov/2022/Paper_12/No.11

The Haber process is carried out with a nitrogen partial pressure of 50 kPa, a hydrogen partial pressure of 150 kPa, a temperature of 400 °C and an iron catalyst.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

If all other conditions are kept the same, which change will result in a raised activation energy?

A Both the nitrogen and hydrogen partial pressures are changed to 100 kPa.

B The iron is removed.

C The nitrogen partial pressure is increased to 150 kPa.

D The temperature is increased to 500 °C.

6. Nov/2022/Paper_22/No.1(c)

(c) NH_4^+ is a Brønsted–Lowry acid.

(i) Define Brønsted–Lowry acid.

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..... [1]

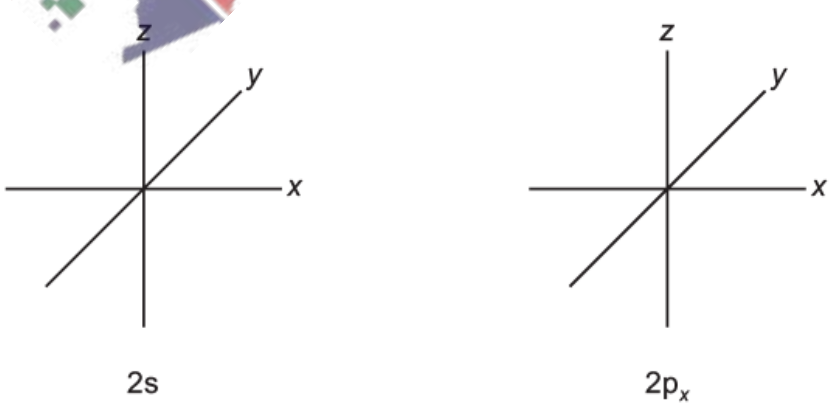
(ii) When $NH_4^+(aq)$ is heated with NaOH(aq), a pungent gas is produced.

Write an ionic equation for this reaction.

..... [1]

(iii) The nitrogen atom in NH_4^+ is sp^3 hybridised. sp^3 orbitals form from the mixing of one 2s and three 2p orbitals.

Sketch the shapes of a 2s and a $2p_x$ orbital on the axes in Fig. 1.1.



2s $2p_x$

Fig. 1.1

[2]

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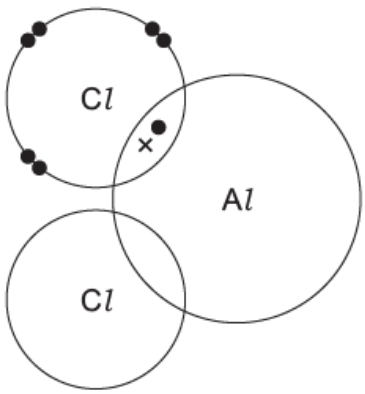
7. Nov/2022/Paper_22/No.2(c)

(c) In the gas phase, $AlCl_3(g)$ exists at equilibrium with $Al_2Cl_6(g)$ as shown.

equation **1** $\quad 2AlCl_3(g) \rightleftharpoons Al_2Cl_6(g) \quad \Delta H_r = -63\,kJ\,mol^{-1}$

(i) Complete the dot-and-cross diagram to show the bonding in Al_2Cl_6.



[2]

(ii) State the effect of an increase in temperature on the equilibrium mixture in equation **1**. Explain your answer.

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..... [1]

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