CHEMISTRY MULTIPLE CHOICE QUESTIONS

G. Equilibria

2002 -2014

1.

For which equilibrium does K_c have *no units*?

A $C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$

B $CH_3OH(l) + CH_3CO_2H(l) \rightleftharpoons CH_3CO_2CH_3(l) + H_2O(l)$

C $Cu^{2+}(aq) + 4NH_3(aq) \rightleftharpoons Cu(NH_3)_4^{2+}(aq)$

D $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

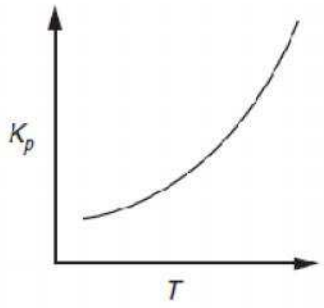
[2002 M/J (10)]

2.

The equilibrium constant K_p for the reaction

$$X(g) + Y(g) \rightleftharpoons Z(g)$$

varies with temperature as shown in the diagram below.



Which conclusions can be drawn from this information?

1 The reaction is exothermic in the forward direction.

2 The equilibrium mixture contains a greater proportion of Z at higher pressures.

3 The equilibrium mixture contains a greater proportion of Z at higher temperatures.

[2002 M/J (34)]

3.

In an experiment, b mol of hydrogen iodide were put into a sealed vessel under pressure p. At equilibrium, x mol of the hydrogen iodide had dissociated, the reaction being represented by the following equation.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

Which expression for K_p is correct?

A $\dfrac{x^2}{(b-x)^2}$

B $\dfrac{x^2p^2}{(b-x)^2}$

C $\dfrac{x^2p^2}{4b(b-x)}$

D $\dfrac{x^2}{4(b-x)^2}$

[2002 O/N (11)]

4.

When 0.20 mol of hydrogen gas and 0.15 mol of iodine gas are heated at 723 K until equilibrium is established, the equilibrium mixture is found to contain 0.26 mol of hydrogen iodide.

The equation for the reaction is as follows.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

What is the correct expression for the equilibrium constant K_c?

A $\dfrac{2 \times 0.26}{0.20 \times 0.15}$

B $\dfrac{(2 \times 0.26)^2}{0.20 \times 0.15}$

C $\dfrac{(0.26)^2}{0.07 \times 0.02}$

D $\dfrac{(0.26)^2}{0.13 \times 0.13}$

[2003 M/J (10)]

5.

Why is ethanoic acid a stronger acid in liquid ammonia than in aqueous solution?

A Ammonia is a stronger base than water.

B Ammonium ethanoate is completely ionised in aqueous solution.

C Ammonium ethanoate is strongly acidic in aqueous solution.

D Liquid ammonia is a more polar solvent than water.

[2003 M/J (11)]

6.

It is suggested that the solid deposits of ammonium compounds on the leaves of trees found in areas of high pollution are caused by the following reaction.

$$2NH_3 + SO_3 + H_2O \rightarrow (NH_4)_2SO_4$$

Which of these take place in this reaction?

1 an acid-base reaction

2 ionic bond formation

3 oxidation and reduction

[2003 O/N (31)]

7.

One explanation of the explosion at the Chernobyl nuclear power plant in 1986 is that the graphite reactor overheated and reacted with the cooling water according to the following equation.

$$C(s) + H_2O(g) \rightleftharpoons H_2(g) + CO(g) \qquad \Delta H = +131\ \text{kJ mol}^{-1}$$

What are possible reasons why the forward reaction is more likely to occur at high temperature?

1 Hydrogen and carbon monoxide do not react at high temperature.

2 At lower temperature, the position of equilibrium lies too far to the left.

3 The energy of activation is high.

[2003 O/N (32)]

8.

When vanadium(II) compounds are dissolved in water, the following equilibrium is established.

$$V^{2+} + H_2O \rightleftharpoons V^{3+} + \tfrac{1}{2}H_2 + OH^-$$

What would alter the composition of the equilibrium mixture in favour of the V^{2+} ions?

A adding an acid

B adding a reagent that selectively precipitates V^{3+} ions

C allowing the hydrogen to escape as it forms

D making the solution more alkaline

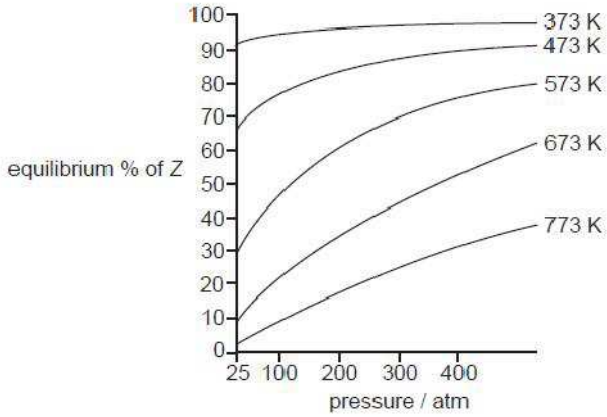
[2004 M/J (10)]

9.

In an industrial process, two gases *X* and *Y* react together to form a single gaseous product *Z*.

$$X(g) + Y(g) \rightleftharpoons Z(g)$$

The percentage yield of product *Z* varies according to the pressure and the temperature as shown in the graphs.



Which statement about this equilibrium reaction is correct?

A Decreasing the temperature decreases the value of the equilibrium constant.

B Decreasing the temperature increases the rate of this reaction.

C Increasing the pressure increases the value of the equilibrium constant.

D The reaction is exothermic in the forward direction.

[2004 M/J (11)]

10.

At high temperatures, steam decomposes into its elements according to the following equation.

$$2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$$

In one experiment at 1 atm pressure, it was found that 20 % of the steam had been converted into hydrogen and oxygen.

What are the values of the equilibrium partial pressures, in atm, of the components of this equilibrium?

	partial pressure of steam	partial pressure of hydrogen	partial pressure of oxygen
A	$\frac{0.80 \times 1}{1.0}$	$\frac{0.10 \times 1}{1.0}$	$\frac{0.10 \times 1}{1.0}$
B	$\frac{0.80 \times 1}{1.0}$	$\frac{0.133 \times 1}{1.0}$	$\frac{0.067 \times 1}{1.0}$
C	$\frac{0.80 \times 1}{1.0}$	$\frac{0.20 \times 1}{1.0}$	$\frac{0.10 \times 1}{1.0}$
D	$\frac{0.80 \times 1}{1.1}$	$\frac{0.20 \times 1}{1.1}$	$\frac{0.10 \times 1}{1.1}$

[2004 O/N (10)]

11.

Which statement concerning the equilibrium reaction below is true?

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

A An increase in acid concentration will result in an increase in the concentration of $Cr_2O_7^{2-}(aq)$.

B A redox reaction is taking place.

C The addition of a catalyst will result in an increase in the concentration of $Cr_2O_7^{2-}(aq)$.

D The equilibrium constant, K_c, has no units.

[2004 O/N (11)]

12.

The dissociation of dinitrogen tetraoxide into nitrogen dioxide is represented by the equation below.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g); \qquad \Delta H^{\ominus} = +57\,kJ\,mol^{-1}$$

If the temperature of an equilibrium mixture of the gases is increased at constant pressure, will the volume of the mixture increase or decrease and why?

A The volume will increase, but only because of a shift of equilibrium towards the right.

B The volume will increase, both because of a shift of equilibrium towards the right and also because of thermal expansion.

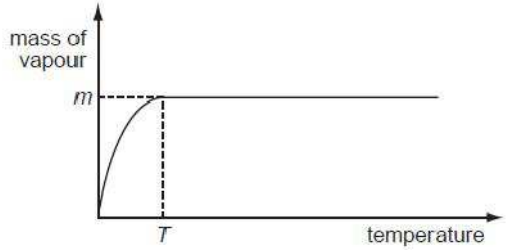
C The volume will stay the same, because any thermal expansion could be exactly counteracted by a shift of equilibrium towards the left.

D The volume will decrease, because a shift of equilibrium towards the left would more than counteract any thermal expansion.

[2005 M/J (10)]

13.

A quantity of solid *Y* was placed in a previously evacuated vessel and the apparatus was then held at a series of different temperatures. At each temperature, the mass of *Y* in the vapour state was calculated from pressure measurements. The results are shown below.



What can be deduced from the diagram?

1 The mass of *Y* used in the experiment was *m*.

2 The pressure of the vapour was constant for all temperatures above temperature *T*.

3 Liquid appeared at temperature *T*.

[2005 M/J (32)]

14.

An experiment is set up to measure the rate of hydrolysis of methyl ethanoate.

$$CH_3CO_2CH_3 + H_2O \rightleftharpoons CH_3CO_2H + CH_3OH$$

The hydrolysis is found to be slow in neutral aqueous solution but it proceeds at a measurable rate when the solution is acidified with hydrochloric acid.

What is the function of the hydrochloric acid?

A to dissolve the methyl ethanoate

B to ensure that the reaction reaches equilibrium

C to increase the reaction rate by catalytic action

D to suppress ionisation of the ethanoic acid formed

[2005 O/N (10)]

15.

At a total pressure of 1.0 atm, dinitrogen tetraoxide is 50 % dissociated at a temperature of 60 °C, according to the following equation.

$$N_2O_4 \rightleftharpoons 2NO_2$$

What is the value of the equilibrium constant, K_p, for this reaction at 60 °C?

A $^1/_3$atm **B** $^2/_3$atm **C** $^4/_3$atm **D** 2 atm

[2006 M/J (10)]

16.

Swimming pool water can be kept free of harmful bacteria by adding aqueous sodium chlorate(I), NaOC*l*. This reacts with water to produce HOC*l* molecules which kill bacteria.

$$OCl\ (aq) + H_2O \rightleftharpoons OH\ (aq) + HOCl(aq)$$

In bright sunshine, the OC*l* ion is broken down by ultra-violet light.

$$OCl\ (aq) + \text{uv light} \rightarrow Cl\ (aq) + \tfrac{1}{2}O_2(g)$$

Which method would maintain the highest concentration of HOC*l*(aq)?

A acidify the pool water

B add a solution of chloride ions

C add a solution of hydroxide ions

D bubble air through the water

[2006 M/J (11)]

17.

The equilibrium constant, K_c, for the reaction to form ethyl ethanoate from ethanol and ethanoic acid, $C_2H_5OH + CH_3CO_2H \rightleftharpoons CH_3CO_2C_2H_5 + H_2O$, at 60 °C is 4.00.

When 1.00 mol each of ethanol and ethanoic acid are allowed to reach equilibrium at 60 °C, what is the number of moles of ethyl ethanoate formed?

A $\frac{1}{3}$ **B** $\frac{2}{3}$ **C** $\frac{1}{4}$ **D** $\frac{3}{4}$

[2006 O/N (11)]

18.

Concentrated sulphuric acid behaves as a strong acid when it reacts with water.

$$H_2SO_4(l) + aq \rightarrow H^+(aq) + HSO_4(aq)$$

The HSO_4 ion formed behaves as a weak acid.

$$HSO_4(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$$

Which statements are true for 1.0 mol dm^{-3} sulphuric acid?

1 $[H^+(aq)]$ is high

2 $[SO_4^{2-}(aq)]$ is high

3 $[HSO_4(aq)] = [SO_4^{2-}(aq)]$

[2006 O/N (32)]

19.

Two equilibria are shown below.

reaction I $\quad 2X_2(g) + Y_2(g) \rightleftharpoons 2X_2Y(g)$

reaction II $\quad X_2Y(g) \rightleftharpoons X_2(g) + \frac{1}{2}Y_2(g)$

The numerical value of K_c for reaction I is 2.

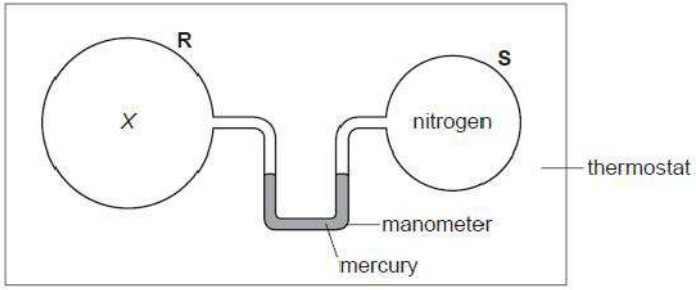
Under the same conditions, what is the numerical value of K_c for reaction II?

A $\frac{1}{\sqrt{2}}$ **B** $\frac{1}{2}$ **C** $\frac{1}{4}$ **D** -2

[2007 M/J (9)]

20.

Two bulbs **R** and **S**, connected by a mercury manometer, are held in a thermostat, as shown. The volume of **R** is twice that of **S**. **R** contains gas, *X*, at the same pressure as the nitrogen in **S**.



When the temperature is increased, which gases in bulb **R** would cause the mercury level in the right-hand limb of the manometer to rise?

1 an equilibrium mixture $N_2F_4(g) \rightleftharpoons 2NF_2(g)$; ΔH positive

2 an equilibrium mixture $CH_3NC(g) \rightleftharpoons CH_3CN(g)$; ΔH negative

3 nitrogen

[2007 M/J (34)]

21.

Nitrogen dioxide decomposes on heating according to the following equation.

$$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$$

When 4 mol of nitrogen dioxide were put into a 1 dm^3 container and heated to a constant temperature, the equilibrium mixture contained 0.8 mol of oxygen.

What is the value of the equilibrium constant, K_c, at the temperature of the experiment?

A $\frac{0.8^2 \times 0.8}{4^2}$ **B** $\frac{1.6 \times 0.8}{2.4^2}$ **C** $\frac{1.6^2 \times 0.8}{4^2}$ **D** $\frac{1.6^2 \times 0.8}{2.4^2}$

[2007 O/N (10)]

22.

Carbon monoxide burns readily in oxygen to form carbon dioxide.

What can be deduced from this information?

1 The +4 oxidation state of carbon is more stable than the +2 state.

2 The standard enthalpy change of formation of carbon dioxide is more negative than that of carbon monoxide.

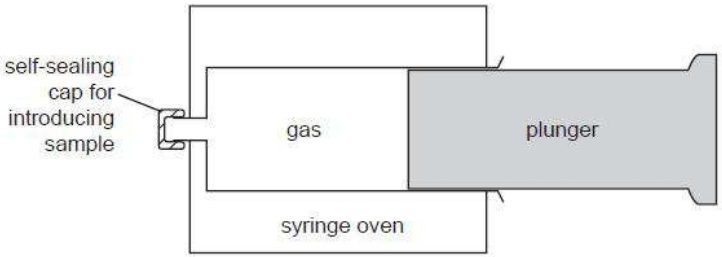
3 The value of the equilibrium constant for the reaction, $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$, is likely to be high.

[2007 O/N (32)]

23.

Phosphorus pentachloride is introduced into an empty gas syringe which has a movable, tightly-fitting plunger. The gas is allowed to expand until equilibrium is reached at a temperature at which the phosphorus pentachloride partially dissociates.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$



Which statements are correct?

1 The equilibrium pressure inside the syringe will be greater than atmospheric pressure.

2 When the plunger is pushed in the equilibrium adjusts to produce more $PCl_5(g)$.

3 The volume of gas in the syringe at equilibrium will be greater than if no dissociation had occurred.

[2007 O/N (33)]

24.

For the reaction

$$W(aq) + 2X(aq) \rightleftharpoons 2Y(aq) + 3Z(aq)$$

what are the correct units for the equilibrium constant K_c?

A $mol\,dm^{-3}$ **B** $mol^2\,dm^{-6}$ **C** $mol^{-1}\,dm^3$ **D** $mol^{-2}\,dm^6$

[2008 M/J (11)]

25.

For the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, what will change the value of K_p?

A adding a catalyst

B adding more O_2

C increasing the pressure

D increasing the temperature

[2008 O/N (10)]

26.

Dinitrogen tetroxide dissociates into nitrogen dioxide on heating.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

In an experiment the partial pressures of the gases at equilibrium were found to be NO_2, 0.33 atm; N_2O_4, 0.67 atm.

What is the numerical value of K_p at the temperature of the experiment?

A 0.16 **B** 0.49 **C** 0.65 **D** 2.03

[2008 O/N (11)]

27.

Under given conditions, what governs the rate of a forward reaction?

1 the activation energy of the reaction

2 the enthalpy change of the reaction

3 the equilibrium constant of the reaction

[2008 O/N (33)]

28.

The following reaction takes place using liquid ammonia as a solvent.

$$Na^+NH_2^- + NH_4^+Cl^- \rightarrow Na^+Cl^- + 2NH_3$$

Which statements best explain why this reaction should be classified as a Brønsted-Lowry acid-base reaction?

1 The ammonium ion acts as a proton donor.

2 Na^+Cl^- is a salt.

3 Ammonia is always basic.

[2009 M/J (34)]

29.

The equilibrium

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \qquad \Delta H = +180\,kJ\,mol^{-1}$$

contributes to a series of reactions producing photochemical smog.

Which factors would affect the value of K_p of the above equilibrium?

	change in pressure	change in temperature	presence or absence of a catalyst
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✓
D	✗	✓	✗

[2009 O/N-11 (8)]

30.

Which equilibria, in which all species are gaseous, would have equilibrium constants, K_p, with no units?

1 sulfur dioxide and oxygen in equilibrium with sulfur trioxide

2 hydrogen and iodine in equilibrium with hydrogen iodide

3 carbon monoxide and steam in equilibrium with carbon dioxide and hydrogen

[2009 O/N-11 (33)]

31.

The table gives the concentrations and pH values of the aqueous solutions of two compounds, X and Y. Either compound could be an acid or a base.

	X	Y
concentration	$2\,mol\,dm^{-3}$	$2\,mol\,dm^{-3}$
pH	6	9

Student P concluded that X is a strong acid.

Student Q concluded that the extent of dissociation is lower in X(aq) than in Y(aq).

Which of the students are correct?

A both P and Q

B neither P nor Q

C P only

D Q only

[2010 M/J-11 (10)]

32.

Swimming pool water can be kept free of harmful bacteria by adding aqueous sodium chlorate(I), NaOC*l*. This reacts with water to produce HOC*l* molecules which kill bacteria.

$$OCl^-(aq) + H_2O \rightleftharpoons OH^-(aq) + HOCl(aq)$$

In bright sunshine, the OCl^- ion is broken down by ultra-violet light.

$$OCl^-(aq) + \text{uv light} \rightarrow Cl^-(aq) + \tfrac{1}{2}O_2(g)$$

Which method would maintain the highest concentration of HOC*l*(aq)?

A acidify the pool water

B add a solution of chloride ions

C add a solution of hydroxide ions

D bubble air through the water

[2010 M/J-11 (11)]

33.

The value of the equilibrium constant, K_c, for the reaction to form ethyl ethanoate from ethanol and ethanoic acid is 4.0 at 60 °C.

$$C_2H_5OH + CH_3CO_2H \rightleftharpoons CH_3CO_2C_2H_5 + H_2O$$

When 1.0 mol of ethanol and 1.0 mol of ethanoic acid are allowed to reach equilibrium at 60 °C, what is the number of moles of ethyl ethanoate formed?

A $\frac{1}{3}$ **B** $\frac{2}{3}$ **C** $\frac{1}{4}$ **D** $\frac{3}{4}$

[2010 O/N-11 (10)]

34.

Ethanol is manufactured by reacting ethene gas and steam in the presence of phosphoric(V) acid.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\,kJ\,mol^{-1}$$

The reaction is carried out at 570 K and 60 atm.

What would be the consequences of carrying out the reaction at the same temperature but at a pressure of 200 atm?

1 The manufacturing costs would increase.

2 The maximum yield at equilibrium would be higher.

3 The reaction would proceed at a faster rate.

[2010 O/N-11 (31)]

35.

The following equilibrium is set up in a mixture of concentrated nitric and sulfuric acids.

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

Which row correctly describes the behaviour of each substance in the equilibrium mixture?

	HNO_3	H_2SO_4	$H_2NO_3^+$	HSO_4^-
A	acid	acid	base	base
B	acid	base	base	acid
C	base	acid	acid	base
D	base	acid	base	acid

[2010 O/N-12 (9)]

36.

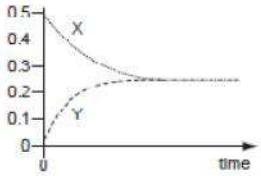
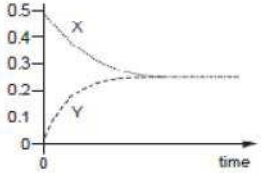
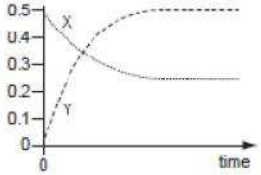
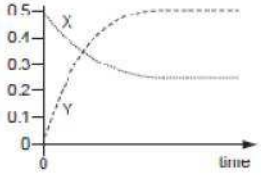
A dimer, X, is stable when solid but a dynamic equilibrium is set up in solution.

$$X(aq) \rightleftharpoons 2Y(aq)$$

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

The changes in [X(aq)] and [Y(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		2
C		1
D		2

[2010 O/N-12 (11)]

37.
Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions are isoelectronic (have the same number of electrons).

D The NH_4^+ ion can donate a proton.

[2010 O/N-12 (15)]

38.
Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?

1 Water can act as either an acid or a base.

2 Sulfuric acid, H_2SO_4, does not behave as an acid when dissolved in ethanol, C_2H_5OH.

3 The ammonium ion acts as a base when dissolved in liquid ammonia.

[2011 M/J-11 (31)]

39.
The esterification reaction

$$\text{ethanol} + \text{ethanoic acid} \rightleftharpoons \text{ethyl ethanoate} + \text{water}$$

is an equilibrium. The forward reaction is exothermic.

How can the value of the equilibrium constant K_C be increased?

A by adding a little concentrated sulfuric acid as a catalyst

B by increasing the initial concentration of ethanol

C by lowering the temperature

D by raising the temperature

[2011 M/J-12 (4)]

40.
Sulfur dioxide is used as a preservative in wine making.

The following equations describe how sulfur dioxide dissolves.

$$H_2O + SO_2 \rightleftharpoons HSO_3^- + H^+$$

$$HSO_3^- + H^+ \rightleftharpoons SO_3^{2-} + 2H^+$$

Which statement about these two reactions is correct?

A HSO_3^- acts as a base.

B SO_2 acts as an oxidising agent.

C SO_3^{2-} acts as an acid.

D SO_3^{2-} acts as a reducing agent.

[2011 O/N-11 (8)]

41.
An aqueous solution was prepared containing 1.0 mol of $AgNO_3$ and 1.0 mol of $FeSO_4$ in 1.00 dm^3 of water. When equilibrium was established, there was 0.44 mol of $Ag^+(aq)$ in the mixture.

$$Ag^+(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$$

What is the numerical value of K_c?

A 0.35 **B** 0.62 **C** 1.62 **D** 2.89

[2011 O/N-11 (9)]

42.
When gaseous iodine is heated with hydrogen at 450 °C, an equilibrium is established.

$$\underset{\text{colourless}}{H_2(g)} + \underset{\text{purple}}{I_2(g)} \rightleftharpoons \underset{\text{colourless}}{2HI(g)} \qquad \Delta H = +53\ kJ\ mol^{-1}$$

Which change of conditions will cause the purple colour of the equilibrium mixture to become paler?

A decrease in pressure

B decrease in temperature

C increase in pressure

D increase in temperature

[2011 O/N-11 (10)]

43.
For the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, what will change the value of K_p?

A adding a catalyst

B adding more O_2

C increasing the pressure

D increasing the temperature

[2011 O/N-12 (7)]

44.
For the reaction

$$W(aq) + 2X(aq) \rightleftharpoons 2Y(aq) + 3Z(aq)$$

what are the correct units for the equilibrium constant K_c?

A $mol\,dm^{-3}$ **B** $mol^2\,dm^{-6}$ **C** $mol^{-1}\,dm^3$ **D** $mol^{-2}\,dm^6$

[2011 O/N-12 (12)]

45.
Two moles of compound P were placed in a vessel. The compound P was partly decomposed by heating. A dynamic equilibrium between chemicals P, Q and R was established.

At equilibrium, x mol of R were present and the total number of moles present was $(2 + x)$.

What is the equation for this equilibrium?

A $P \rightleftharpoons 2Q + R$

B $2P \rightleftharpoons 2Q + R$

C $2P \rightleftharpoons Q + R$

D $2P \rightleftharpoons Q + 2R$

[2012 M/J-11 (9)]

46.
Two moles of compound P were placed in a vessel. The vessel was heated and compound P was partly decomposed to produce Q and R. A dynamic equilibrium between chemicals P, Q and R was established.

At equilibrium x moles of R were present and the total number of moles present was $(2 + \frac{x}{2})$.

What is the equation for this equilibrium reaction?

A $P \rightleftharpoons 2Q + R$

B $2P \rightleftharpoons 2Q + R$

C $2P \rightleftharpoons Q + R$

D $2P \rightleftharpoons Q + 2R$

[2012 M/J-12 (7)]

47.
Methanol is manufactured by reacting carbon dioxide and hydrogen.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \qquad \Delta H = -49\,kJ\,mol^{-1}$$

What would increase the equilibrium yield of methanol in this process?

A adding a catalyst

B adding an excess of steam

C increasing the pressure

D increasing the temperature

[2012 M/J-12 (9)]

48.
Concentrated sulfuric acid behaves as a strong acid when it reacts with water.

$$H_2SO_4(l) + aq \rightarrow H^+(aq) + HSO_4^-(aq)$$

The HSO_4^- ion formed behaves as a weak acid.

$$HSO_4^-(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$$

Which statements are true for $1.0\,mol\,dm^{-3}$ sulfuric acid?

1 $[H^+(aq)]$ is high

2 $[SO_4^{2-}(aq)]$ is high

3 $[HSO_4^-(aq)] = [SO_4^{2-}(aq)]$

[2012 M/J-12 (33)]

49.

The table describes some of the chemistry and thermodynamic properties of the halogens.

process	name and symbol of quantity
$2HX(g) \rightarrow H_2(g) + X_2(g)$	enthalpy change of reaction, $\Delta H^{\ominus}$
$H_2(g) + X_2(g) \rightleftharpoons 2HX(g)$	equilibrium constant, K_p
$X(g) \rightarrow X^+(g) + e^-$	ionisation energy, $\Delta H_i^{\ominus}$

Which statements about the relative values of these quantities are correct?

1 $\Delta H^{\ominus}$ for HC*l* > $\Delta H^{\ominus}$ for HBr

2 K_p for HBr > K_p for HI

3 $\Delta H_i^{\ominus}$ for I > $\Delta H_i^{\ominus}$ for C*l*

[2012 O/N-13 (36)]

50.

An experiment is set up to measure the rate of hydrolysis of ethyl ethanoate.

$$CH_3CO_2C_2H_5 + H_2O \rightleftharpoons CH_3CO_2H + C_2H_5OH$$

The hydrolysis is found to be slow in neutral aqueous solution but it proceeds at a measurable rate when the solution is acidified with hydrochloric acid.

What is the function of the hydrochloric acid?

A to dissolve the ethyl ethanoate

B to ensure that the reaction reaches equilibrium

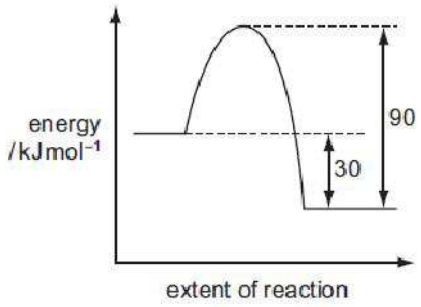
C to increase the reaction rate by catalytic action

D to suppress ionisation of the ethanoic acid formed

[2013 M/J-11 (6)]

51.

The diagram shows the reaction pathway for a reversible reaction.



Which statements are correct?

1 The enthalpy change for the backward reaction is +90 kJ mol^{-1}.

2 The forward reaction is exothermic.

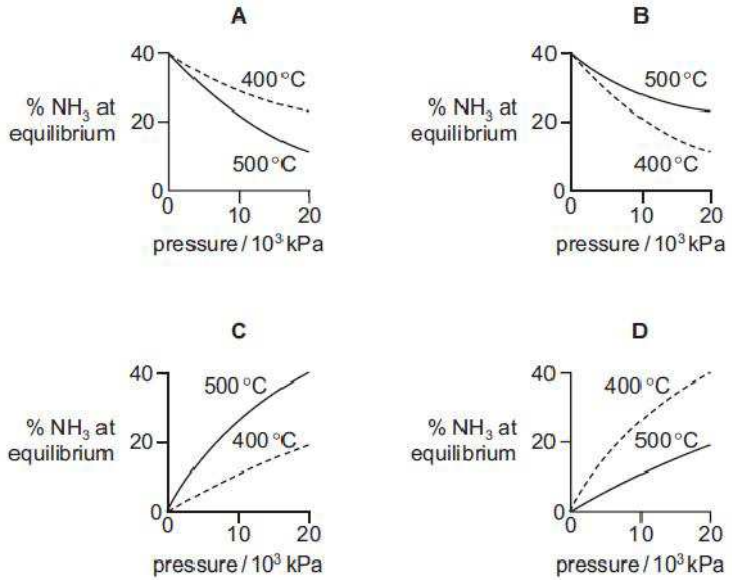
3 The enthalpy change for the forward reaction is −30 kJ mol^{-1}.

[2013 M/J-12 (32)]

52.

Graphs can be drawn to show the percentage of ammonia at equilibrium when nitrogen and hydrogen are mixed at different temperatures and pressures.

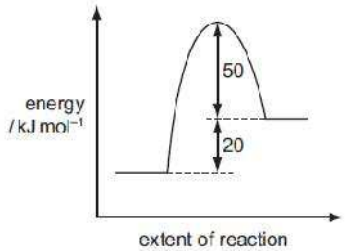
Which diagram correctly represents these two graphs?



[2013 M/J-13 (17)]

53.

The reaction pathway for a reversible reaction is shown below.



Which statements are correct?

1 The enthalpy change for the backward reaction is $-20\,kJ\,mol^{-1}$.

2 The forward reaction is endothermic.

3 The activation energy for the forward reaction is $+70\,kJ\,mol^{-1}$.

[2013 M/J-13 (33)]

54.

Nitrogen reacts with hydrogen to produce ammonia.

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

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen, and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3 under certain conditions. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c under these conditions?

A $\frac{(1.76)^2}{(2.32)(6.96)^3}$

B $\frac{(1.76)^2}{(2.32)(6.32)^3}$

C $\frac{(2.08)^2}{(2.32)(6.32)^3}$

D $\frac{(2.40)^2}{(2.32)(6.00)^3}$

[2013 O/N-11 (9)]

55.

What are necessary properties of a dynamic equilibrium?

1 Equal amounts of reactants and products are present.

2 Concentrations of reactants and products remain constant.

3 The rate of the forward reaction is the same as the rate of the reverse reaction.

[2013 O/N-11 (33)]

56.

If N_2O_4 gas is placed in a sealed vessel the following equilibrium is established.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

The forward reaction is endothermic.

What happens when the temperature is increased?

1 The equilibrium constant increases.

2 The partial pressure of NO_2 increases.

3 The activation energy is unchanged.

[2013 O/N-11 (34)]

57.

Nitrogen reacts with hydrogen to produce ammonia.

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

A mixture of 1.00 mol of nitrogen, 3.00 mol of hydrogen and 1.98 mol of ammonia is allowed to reach equilibrium in a sealed vessel under certain conditions. It was found that 1.64 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c under these conditions?

A $\frac{(0.70)^2}{(1.64)(4.92)^3}$

B $\frac{(1.34)^2}{(1.64)(3.64)^3}$

C $\frac{(1.64)(4.92)^3}{(0.70)^2}$

D $\frac{(1.64)(3.64)^3}{(1.34)^2}$

[2013 O/N-13 (10)]

58.

The following equilibrium is an exothermic reaction in the forward direction.

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

What happens when the concentration of CrO_4^{2-} ions **increases and** the temperature **decreases**?

1 The concentration of $Cr_2O_7^{2-}$ ions increases.

2 The equilibrium constant increases.

3 The activation energy decreases.

[2013 O/N-13 (34)]

59.

The equilibrium constant, K_c, for the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, is 60 at 450 °C.

What is the number of moles of hydrogen iodide in equilibrium with 2 mol of hydrogen and 0.3 mol of iodine at 450 °C?

A $\frac{1}{100}$ B $\frac{1}{10}$ C 6 D 36

[2014 M/J-11 (10)]

60.

R and S react together.

$$R + S \rightleftharpoons T$$

Which factors affect the rate of the forward reaction?

1 the activation energy of the reaction

2 the enthalpy change of the reaction

3 the equilibrium constant of the reaction

[2014 M/J-11 (33)]

61.

The Brønsted-Lowry theory describes acid and base character.

When concentrated sulfuric acid and concentrated nitric acid are mixed, the following reactions occur.

$$H_2SO_4 + HNO_3 \rightleftharpoons HSO_4^- + H_2NO_3^+$$

$$H_2NO_3^+ \rightleftharpoons H_2O + NO_2^+$$

$$H_2O + H_2SO_4 \rightleftharpoons HSO_4^- + H_3O^+$$

Which species are bases in these reactions?

1 HSO_4^-

2 HNO_3

3 NO_2^+

[2014 M/J-11 (34)]

62.

Hydrogen and carbon dioxide gases are mixed in equal molar amounts at 800K. A reversible reaction takes place.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

At equilibrium, the partial pressures of H_2 and CO_2 are both 10.0 kPa. K_p is 0.288 at 800K.

What is the partial pressure of CO in the equilibrium mixture?

A 5.37 kPa **B** 18.6 kPa **C** 28.8 kPa **D** 347 kPa

[2014 M/J-12 (4)]

63.

The formation of hydrogen and ethyne, C_2H_2, from methane reaches dynamic equilibrium.

$$2CH_4(g) \rightleftharpoons 3H_2(g) + C_2H_2(g)$$

What are the units of K_c?

A $mol\,dm^{-3}$ **B** $mol^2\,dm^{-6}$ **C** $mol^3\,dm^{-9}$ **D** $mol^4\,dm^{-12}$

[2014 M/J-12 (7)]

64.

Sulfuric acid is a Brønsted-Lowry acid.

In which reactions is sulfuric acid behaving as an acid?

1 $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$

2 $H_2SO_4 + CO_3^{2-} \rightarrow CO_2 + H_2O + SO_4^{2-}$

3 $H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$

[2014 M/J-12 (34)]

65.

A reversible reaction is catalysed.

Which statements about the effects of the catalyst on this system are correct?

1 The catalyst alters the mechanism of the reaction.

2 The catalyst reduces the activation energy for both the forward and the backward reaction.

3 The catalyst alters the composition of the equilibrium mixture.

[2014 O/N-11 (33)]