Acids and Bases

Question Paper

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Acids and Bases- Equilibria
Booklet	Question Paper

Time Allowed: **65 minutes**

Score: **/54**

Percentage: **/100**

Grade Boundaries:

1. **(a)** When aqueous barium chloride is added to a solution containing sulfate ions a white precipitate of barium sulfate is formed. This white precipitate is very sparingly soluble in water.

(i) Write the **ionic** equation, including state symbols, for the formation of the white precipitate.

.....[1]

(ii) Write the expression for the solubility product, K_{sp}, of barium sulfate.

[1]

(iii) Given that K_{sp} for barium sulfate is $1.08 \times 10^{-10}\,mol^2\,dm^{-6}$ at 298 K, calculate the concentration of sulfate ions in a saturated solution of barium sulfate. Give your answer to **three** significant figures.

..... $mol\,dm^{-3}$ [2]

(iv) Regulations state that the maximum permitted level of sulfate ions in drinking water is 250 mg dm^{-3} (1 mg = 1 × 10^{-3} g).

200 cm^3 of aqueous barium chloride was added to 300 cm^3 of drinking water and a white precipitate formed. Assume that the sample of water contained the maximum permitted level of sulfate ions. Calculate the minimum concentration, in mol dm^{-3}, of barium chloride in the solution that was added to the sample of drinking water.

..... mol dm^{-3} [3]

(b) The electrode potential of silver in contact with a solution of silver ions, $Ag^+(aq)$, is impossible to measure directly but can be measured using a standard hydrogen electrode. Using this method the standard electrode potential of silver, $E^{\ominus}$, is found to be +0.80 V.

(i) Complete the cell diagram in Fig. 2.1 for the cell used to measure the standard electrode potential of silver. State the concentration of $H^+(aq)$ used.

_ _ _ _ _ | H_2 (g) | $2H^+(aq)$ || _ _ _ _ _ _ _ _ _ _ _ _ _ _

Fig. 2.1

concentration of $H^+(aq)$ = ...[3]

(ii) When an excess of aqueous sodium chloride is added to the right-hand half-cell the silver ions will be precipitated as solid silver chloride, AgC*l*. Use Le Chatelier's principle to explain qualitatively how the cell emf will change as a result.

.....

.....

.....

..... [2]

(iii) At 298 K the expression below can be used to calculate the concentration of silver ions in solution under non-standard conditions, from a measurement of the electrode potential.

$$E = E^{\ominus} - 0.030 \log \frac{1}{[Ag^{+}(aq)]^2}$$

E = electrode potential of silver under non-standard conditions
$E^{\ominus}$ = standard electrode potential of silver = +0.80 V

The addition of excess aqueous sodium chloride, NaC*l*(aq), to the right-hand half-cell results in a chloride ion concentration of 2.1 mol dm^{-3}.

Given that K_{sp} for silver chloride, AgC*l*, is 1.8×10^{-10} mol^2 dm^{-6} at 298 K, calculate the value of E, in the cell shown in Fig. 2.1, after the addition of the excess aqueous sodium chloride to the right-hand half-cell.

E = ... V [3]

[Total: 15]

2. At 298 K the nitrogen and oxygen in air do not react together at a significant rate. However, a car engine produces about 4 g per mile of nitrogen monoxide because the reaction shown in equation 1.1 occurs much more quickly at the high temperatures that exist in the engine.

equation 1.1 $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

(a) (i) State Le Chatelier's principle.

.....

.....

..... [1]

(ii) Give the expression for K_p for the reaction shown in equation 1.1.

[2]

(iii) At 298 K the value of K_p for the reaction in equation 1.1 is 5.0×10^{-31} while at 1500 K its value is 1.0×10^{-5}.
Use this information to explain whether the formation of nitrogen monoxide is endothermic or exothermic.

.....

.....

.....

..... [2]

(iv) State and explain the effect of an increase in pressure on the position of the equilibrium shown in equation 1.1.

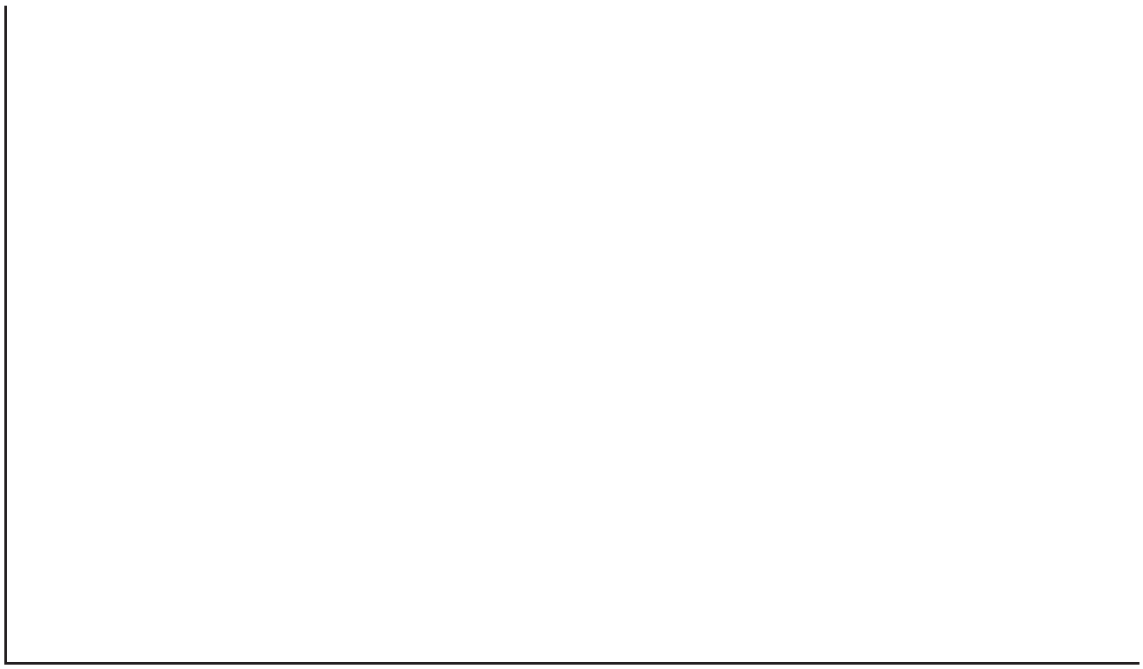
.....

.....

.....

..... [2]

(b) **(i)** Sketch two Boltzmann distribution curves on the axes below to represent the distributions of molecular energies in a sample of gas at two temperatures, $\mathbf{T_1}$ and $\mathbf{T_2}$, where $\mathbf{T_2}$ is significantly higher than $\mathbf{T_1}$. Label the curves clearly to show which one represents which temperature and add titles to the axes.



[4]

(ii) Use the curves to explain why the reaction shown in equation 1.1 occurs so much more quickly in the car engine than at 298 K.

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.....

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..... [3]

[Total: 14]

3. Fig. 1.1 shows the pH changes during the addition of 0.200 mol dm^{-3} HNO_3 to 20.0 cm^3 of a solution of sodium carbonate, Na_2CO_3.

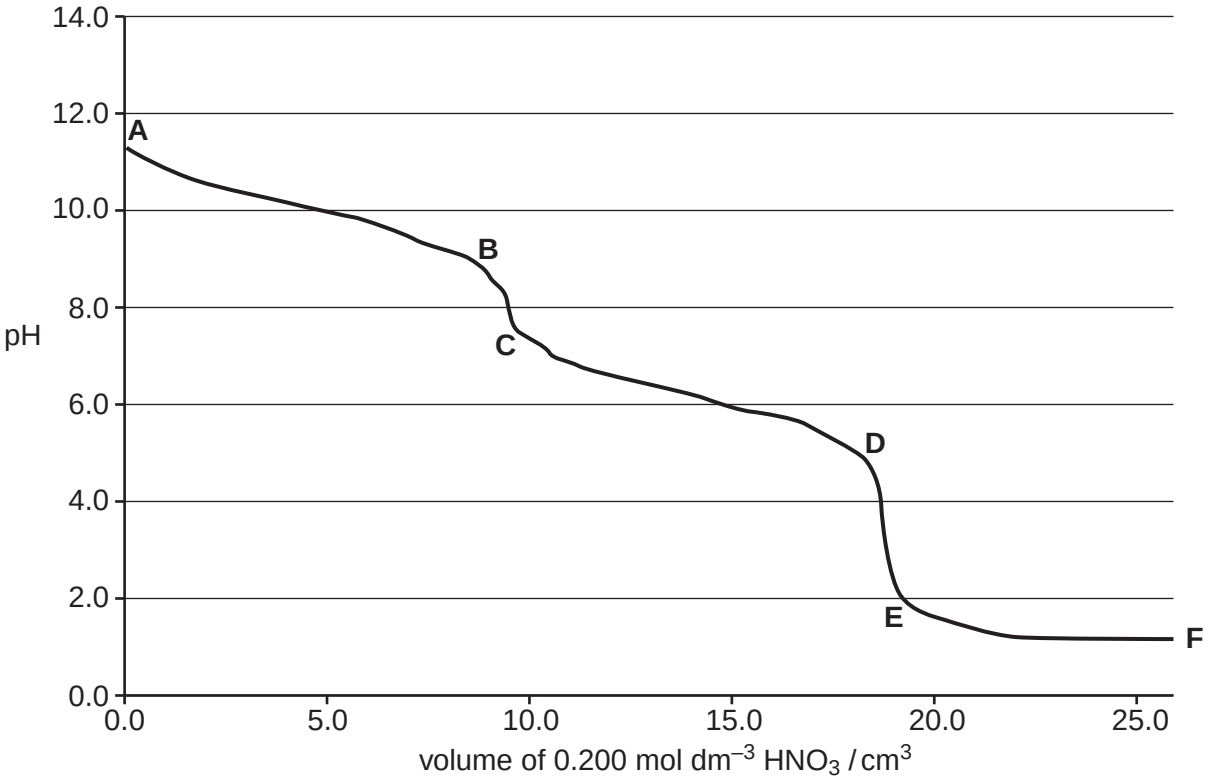

Fig. 1.1

(a) Write **ionic** equations for the reactions which occur in the solution between point **A** and point **B** on the graph and between point **C** and point **D** on the graph.

(i) ionic equation for the reaction occurring between **A** and **B**

.....[1]

(ii) ionic equation for the reaction occurring between **C** and **D**

.....[1]

(b) Table 1.1 gives some information about seven different indicators.

Table 1.1

indicator	pK_a	acid form	base form
thymol blue	1.6	yellow	blue
methyl yellow	3.3	red	yellow
chlorophenol red	6.0	yellow	red
bromothymol blue	7.1	yellow	blue
cresol purple	8.3	yellow	purple
thymolphthalein	9.9	colourless	blue
alizarin yellow	11.0	yellow	red

(i) From the information given in Table 1.1 choose the indicator that would be most suitable for determining the end-point occurring between points **D** and **E** on the graph.

.....[1]

(ii) Explain your choice.

.....

.....[1]

(iii) What colour change will be seen with this indicator at the end-point?

.....[1]

(c) Calculate the concentration, in g dm^{-3}, of sodium carbonate present in the original solution, given that the end-point between **D** and **E** occurs after 18.80 cm^3 of HNO_3 have been added.

..... g dm^{-3} [3]

(d) (i) Write an equation for the dissociation of water.

.....[1]

(ii) Use the equation in **(d)(i)** to write an expression for the equilibrium constant, K_c, for this reaction. Use this expression to show that $K_w = [H^+][OH^-]$. Justify and explain your reasoning.

.....

.....[3]

(iii) At 373 K the ionic product of water, K_w, has a value of 51.3×10^{-14} mol^2 dm^{-6}. Use this information to calculate the pH of water at 373 K. Give your answer to 3 significant figures.

.....[3]

(iv) At 298 K the pH of water is 7.00. Use this information to state whether the dissociation of water is endothermic or exothermic and explain your answer.

.....

.....

.....[2]

(e) Calculate the final pH, at 298 K, after a 5.00 cm^3 portion of 1.00 mol dm^{-3} hydrochloric acid is added separately to

(i) 100 cm^3 of a solution of 1.00 × 10^{-4} mol dm^{-3} hydrochloric acid.

pH = ... [4]

(ii) 100 cm^3 of a solution that contains 0.100 mol dm^{-3} ethanoic acid and 0.100 mol dm^{-3} sodium ethanoate.
(K_a for ethanoic acid is 1.70 × 10^{-5} mol dm^{-3} at 298 K)

pH = ... [4]

[Total: 25]