# Mark Scheme - AS 1.7 Equilibria and Acid-base Reactions

1. (a) Benefits:
Stops fossil fuels from running out
Reduces $CO_2$ emissions / greenhouse emissions / global warming / effect of global warming
Reduces $SO_2$ emissions / acid rain
There will be an investment in new technology

Difficulties:
Dependence on fossil fuel/Unlikely to meet current demand
Renewable energy currently more expensive
Reliability of supply from renewables
Major development in energy efficiency technologies required
Opposition by vested interests
(Maximum 3 marks from list, but need examples of both) (3)

Consideration and discussion of benefits/difficulties (1) [4]

*QWC* Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning [1]

(b) (i) I As temperature increases yield decreases
As pressure increases yield decreases [1]

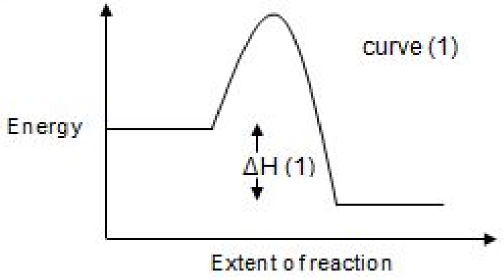
II As temperature is increased, equilibrium moves to the left (1)
Therefore forward reaction is exothermic (1)
As pressure is increased, equilibrium moves to the left (1)
Therefore more gas moles in products (1) [4]
*QWC* The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(ii) If temperature is too low, then reaction is too slow (1)
If temperature is too high, yield is too low (1)
Compromise temperature – acceptable rate and yield (1)
(Accept any two points) [2]

(iii) Heterogenous catalyst [1]

(iv) Lower temperatures could be used (1)
Less energy consumption / increased yield (1)
Equilibrium could be reached more quickly (1)
(Accept any two points) [2]

**(v)**



[2]

(vi) $\Delta H = E_f - E_b$ [1]

**Total [19]**

**2.**

(a) (a reaction in which) the rate of the forward reaction is equal to the rate of the backward reaction [1]

(b) goes darker / more brown (1)

because the (forward) reaction has a +ve ΔH / is endothermic (1)

goes paler / less brown (1)

because there are more moles / molecules on RHS (1)

no change (because catalysts do not affect the position of an equilibrium) (1) [5]

(c) (i) moles $N_2H_4$ = 14000/32.04 = 437.0 (1)

this produces 437.0 × 3 = 1311 moles of gas (1)

volume = 1311 × 24 = $3.15 \times 10^4$ $dm^3$ (1) [minimum 2 sf] [3]

(ii) (large volume of) gas produced [1]

(d) (i) an acid is a proton / $H^+$ donor [1]

(ii) $\rightarrow NO_2^- + H_3O^+$ [1]

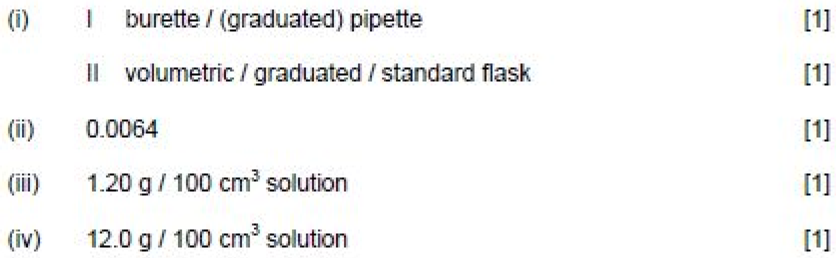
(iii) sulfuric acid is behaving as the acid / nitric acid is behaving as a base (1)

as it donates a proton / as it accepts a proton (1) [2]

**Total [14]**

## 3.

(a)



(i) I burette / (graduated) pipette [1]

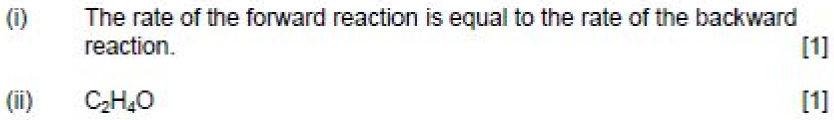
II volumetric / graduated / standard flask [1]

(ii) 0.0064 [1]

(iii) 1.20 g / 100 $cm^3$ solution [1]

(iv) 12.0 g / 100 $cm^3$ solution [1]

(b)



(i) The rate of the forward reaction is equal to the rate of the backward reaction. [1]

(ii) $C_2H_4O$ [1]

## 4.

Acid: Proton donor (1)

Dynamic equilibrium: Reversible reaction where the **rate** of forward and reverse reactions is equal (1) [2]

## 5.

*(a)* Name of any commercially/ industrially important chlorine containing compound e.g. (sodium) chlorate(I) as bleach/ (sodium) chlorate(V) as weedkiller/ aluminium chloride as catalyst in halogenation
- do not accept CFCs **[1]**

*(b)* (i) $K_c = \dfrac{[HI]^2}{[H_2][I_2]}$ must be square brackets **[1]**

(ii) $K_c = \dfrac{0.11^2}{3.11^2} = 1.25 \times 10^{-3}$ follow through error (ft) **[1]**

(iii) $K_c$ has no units ft **[1]**

(iv) when temperature increases $K_c$ increases (1)

this means equilibrium has moved to RHS
/ increasing temperature favours endothermic reaction (1)

therefore ΔH for forward reaction is +ve (1)
(mark only awarded if marking point 2 given) **[3]**

## 6.

(a) (i) Cold $Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$ (1)

Warm $3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 + 3H_2O$ (1)

[2]

(ii) Disproportionation [1]

(b) (i) $K_c = \dfrac{[CH_3COOCH_3][H_2O]}{[CH_3COOH][CH_3OH]}$ (1)

No units (1) [2]

(ii) moles $= \dfrac{1.25 \times 32.0}{1000} = 0.04(0)$ [1]

(iii) $[CH_3COOH] = 0.04$, therefore 0.06 used in reaction and

$[CH_3COOCH_3] = 0.06$, $[H_2O] = 0.06$ and

$[CH_3OH] = 0.083 - 0.06 = 0.023$ (1)

$K_c = \dfrac{0.06 \times 0.06}{0.04 \times 0.023} = 3.91$ (1) [2]

(iv) Value of $K_c$ decreases since the equilibrium shifts to the left / the forward reaction is exothermic [1]

7.

(a)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| *Volume used / cm$^3$* | 20.75 | 20.20 | 20.10 | 20.30 |

[1]

(b) 20.20 cm$^3$ [1]

8. (a) (i) $K_p = \dfrac{pSO_3(g) \times pNO(g)}{pSO_2(g) \times pNO_2(g)}$ (1) there are no units (1) [2]

(ii) The line for $SO_3$ / NO at equilibrium should be above the $SO_2$ / $NO_2$ line (1)
as $K_p$ has a value of 2.5, the partial pressures of $SO_3$ and NO at equilibrium will be greater than the partial pressures of $SO_2$ and $NO_2$. (1)

- accept answer in terms of alternative calculated $K_p$ value

The line for equilibrium should start at 9 hours. (1)
as at equilibrium the concentrations is unchanged as time progresses. (1)
[4]

There may be other acceptable forms of explanation to be discussed at the conference

(iii) If the temperature rises then the position of equilibrium will move to the left, (reducing the quantities of $SO_3$ and NO). (1)
This will make the value of $K_p$ smaller. (1) [2]

(b) (i) Nitric acid is a strong acid and its pH is low / <2 / 1.0 (1)
As aqueous ammonia is added the pH slowly rises (1) until a pH of ~3 is reached, when it rises rapidly (1)
At a pH of 8-9, it tails off slowly as ammonia is a weak base. (1)
Accept any 3 from 4 [3]

*Selection of a form and style of writing which is appropriate to purpose and to complexity of subject matter* [1]

(ii) The equivalence point is reached when 20.0 $cm^3$ of ammonia solution has been added as this is at the mid point of the more vertical section. (1)

Since both reagents have the same concentration and the volumes used are both 20 $cm^3$ / the same, the number of moles of each are the same (1)

OR the number of moles of both nitric acid and aqueous ammonia are calculated (0.0020) and shown to be the same (1)

∴ Mole ratio must be 1 : 1 (1) [2]

(iii) I Ammonium nitrate is the salt of a strong acid and weak base / there is a buffering effect in operation. [1]
II ~ 6.4 [1]

(iv) Blue, as bromophenol blue is blue at a pH of 4.7 and above [1]

(c) Number of moles of ammonium nitrate $= \dfrac{40}{80} = 0.50$ (1)

- error carried forward

Concentration of ammonium nitrate solution $= \dfrac{0.5 \times 1000}{200} = 2.5 \text{ mol dm}^{-3}$ (1)

∴ Temperature drop = 2.5 × 6.2 = 15.5°C (1) [3]

Total [20]

9.

(a) $x = 10$ **[1]**

(b) (i) number of moles = 250 x 0.200 ÷ 1000 = 0.05 mol (1) – ft

mass of sodium carbonate = 0.05 x $M_r(Na_2CO_3)$ = 0.05 x 286.2
= 14.31g (1) **[2]**

(ii) any two points from:

weigh by difference (1)

add less water initially (1)

wash out beaker / glass rod / funnel and put water into volumetric flask (1)

add water up to mark in volumetric flask (1)
- 2 max **[2]**

(c) add few drops of indicator (1) do not accept 'universal indicator'

take initial and final reading on burette (1)

swirl the conical flask (1)

add acid until the indicator changes colour (1) **[4]**

*QWC: organisation of information clearly and coherently; use of specialist vocabulary where appropriate.* *QWC* **[1]**

**Total [10]**

10.

(a) $K_w = [H^+][OH^-]$ (1)
Units = $mol^2\,dm^{-6}$ (1) [2]

(b) (i) In pure water $[H^+] = [OH^-]$ or $[H^+] = \sqrt{1.0 \times 10^{-14}}$ (1)
pH = $-\log 10^{-7} = 7$ (1) [2]

(ii) Final volume of solution is 1000 $cm^3$ so acid has been diluted by a factor of 100 so final concentration of acid is 0.001

or moles acid = $\dfrac{0.1 \times 10}{1000} = 0.001$ (1)

pH = $-\log 0.001 = 3$ (1) [2]

(c) $1.78 \times 10^{-5} = \dfrac{[H^+] \times 0.02}{0.01}$ (1)

$[H^+] = 8.90 \times 10^{-6}$ (1)

pH = 5.05 allow 5 or 5.1 (1) [3]

(d) The solution is a buffer (1)

Solution contains a large amount of $CH_3COOH$ and $CH_3COO^-$ ions

(Accept correct equations) (1)

When an acid is added, the $CH_3COO^-$ ions react with the $H^+$ ions, removing them from solution and keeping the pH constant (1) [3]

**Total [12]**

**11.** *(a)* an acid is a proton / $H^+$ donor **[1]**

*(b)* pH = $-\log[H^+]$ / negative log of hydrogen ion concentration **[1]**

*(c)* a low pH corresponds to a high concentration of $H^+$ (1)

a strong acid is totally dissociated whilst a weak acid is partially dissociated (1)

need to consider concentration (of acid solution) as well as strength of the acid (1)

a concentrated solution of a weak acid could have a lower pH than a dilute solution of a strong acid (1) **[4]**

*QWC Accuracy of spelling, punctuation and grammar* *QWC* **[1]**

*(d)* (i) $K_a = \frac{[HCOO^-][H^+]}{[HCOOH]}$ **[1]**

(ii) $1.75 \times 10^{-4} = \frac{x^2}{0.1}$ (1)

$x = 4.183 \times 10^{-3}$ (1)

pH = 2.38 (1) **[3]**

*(e)* (i) buffer **[1]**

(ii) $RCOOH \rightleftharpoons RCOO^- + H^+$ and $RCOONa \rightarrow RCOO^- + Na^+$ (1)

added $H^+$ removed by salt anion/ $A^- + H^+ \rightarrow HA$ (1)

added $OH^-$ removed by acid/ $OH^- + HA \rightarrow A^- + H_2O$ (1) **[3]**

**Total [15]**

12.

(a) (dissociates to) release $H^+$ ions **[1]**

(b) 2.5-6.0 **[1]**