ACIDS AND BASES Core (SL & HL)

1. (a) Sulfuric acid, H_2SO_4 (aq) is a strong acid.

(i) What is the conjugate base of sulfuric acid?

[1]

HSO_4^- (aq.) ✓

state symbol not required
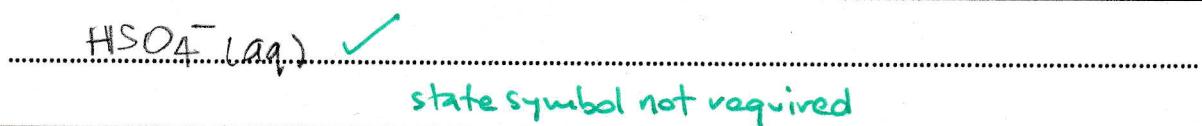
(ii) Calculate the pH of a 0.014 mol dm^{-3} solution of H_2SO_4 (aq).

[2]

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$ (complete dissociation)

$[H^+] = 0.014 \times 2 = 0.028$ ✓

$pH = -\log_{10} 0.028 = 1.6$ ✓ (allow ect).

1.85 scores 1
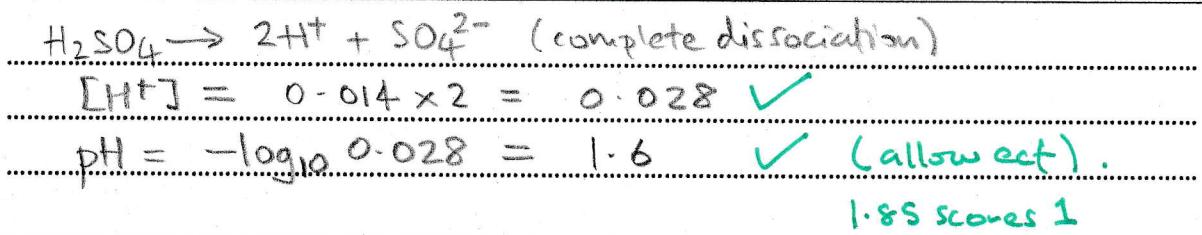
(iii) Write an equation to show the reaction between sulfuric acid and solid sodium carbonate. Include state symbols.

[2]

$H_2SO_4 (aq) + Na_2CO_3 (s) \rightarrow Na_2SO_4 (aq) + H_2O (l) + CO_2 (g)$

✓ equation   ✓ state symbols
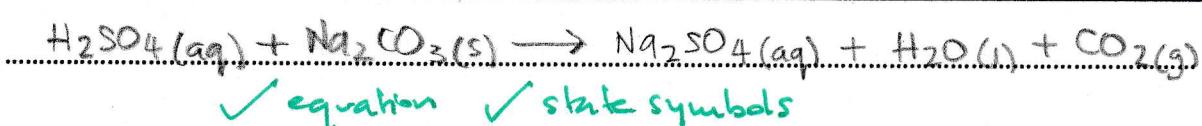
(b) Ethanoic acid is a weak acid: CH_3CO_2H (aq) $\rightleftharpoons$ $CH_3CO_2^-$ (aq) + H^+ (aq)

(i) Explain why ethanoic acid is considered to be a weak acid.

[1]

Ethanoic acid (only) partially dissociates into ions in solution. ✓

(ii) State and describe the outcome of one way in which you might tell the difference between samples of ethanoic acid and sulfuric acid of equal concentrations. (No practical detail is required).

[2]

Measure pH ✓ ; pH of sulfuric will be lower. ✓

Reaction with magnesium ribbon ; sulfuric will react more vigorously / greater bubbling etc.

Electrical conductivity ; sulfuric acid will be higher.

any 1 method and outcome.

2. (a) Carbonated water contains dissolved CO_2 which causes the water to be acidic:

$$CO_2 (aq) + H_2O (l) \rightleftharpoons HCO_3^- (aq) + H^+ (aq)$$
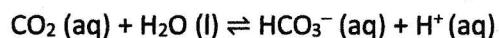
(i) State the formula for the conjugate acid of HCO_3^- (aq).

[1]

$H_2CO_3 (aq)$ ✓

State symbol not required

(ii) Identify an amphiprotic species present in the reaction, and explain your reasoning.

[2]

HCO_3^- (or H_2O) ✓

Can both donate or accept a proton/H^+ ion ✓

(iii) A sample of carbonated water has a pH of 4.5. Calculate the concentration of H^+ (aq) ions **and** the concentration of OH^- (aq) ions in the solution.

[3]

$[H^+] = 10^{-4.5} = 3.2 \times 10^{-5}$ mol dm^{-3} ✓

$pH + pOH = 14$ or $[H^+][OH^-] = 1 \times 10^{-14}$ ✓

$[OH^-] = 10^{-9.5} = 3.2 \times 10^{-10}$ mol dm^{-3} ✓

Correct answers score 3. allow 3.1–3.2 for $[OH^-]$
$\times 10^{-10}$

3. (a) State a gas that generates acid deposition and write an equation to show how the gas reacts with water in the atmosphere.

[2]

Sulfur dioxide, SO_2 or SO_3, NO, NO_2 etc.

$SO_2 + H_2O \rightarrow H_2SO_3$ or $SO_3 + H_2O \rightarrow H_2SO_4$

~~$O_2 + 2NO + H_2O \rightarrow H_2NO_3 + HNO_2$~~

or $2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$

(b) State a problem that acid deposition causes and explain one way of preventing acid deposition.

[2]

damages limestone buildings / kill trees / kill water life *any 1* ✓

'wet scrubbing' reacting gases with $CaCO_3$ in chimneys ✓

or catalytic converter (metal catalysts) $NO_2 \rightarrow \frac{1}{2}N_2 + O_2$ ✗

(✓)

Total 18 marks (27 minutes)