# Assessment Schedule – 2008

# Chemistry: Describe thermochemical and equilibrium principles (90310)

## Evidence Statement

| Q | Evidence | Achievement | Achievement with Merit | Achievement with Excellence |
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| ONE (a) | The reaction rate is increased when manganese dioxide is added. | Correct statement. | | |
| (b) | The catalyst increases the reaction rate by providing an alternative pathway of lower activation energy. Therefore a greater proportion of collisions (in a given time) have the required activation energy and are successful. | Describes the effect of a catalyst on the activation energy. | Explanation of the role of a catalyst in terms of successful particle collisions and activation energy. | |
| (c) | Time period A:<br>Initially the reaction rate is high, as the concentration of reactants in the solution is high. As the reaction proceeds, the reaction rate decreases because the concentration of reactants is decreased, the collision rate of reactant particles is decreased.<br>Time period B:<br>The reaction has stopped / zero reaction rate. There are no more (or few) $H_2O_2$ particles left to collide, so no more oxygen is being produced. | ONE of:<br>Rate of reaction is high in A (NOT increasing)<br>OR<br>rate decreased overall in A<br>OR<br>stopped in B. | PLUS reason<br>for initial rate<br>OR<br>decreasing rate in time period A<br>OR<br>zero reaction rate in time period B. | Discussion of BOTH the initial reaction rate AND the decreasing rate in time period A<br>AND<br>zero reaction rate in time period B. |
| TWO (a)<br>(b) | $K_c = \dfrac{[NO]^2}{[N_2][O_2]}$<br>$K_c = \dfrac{[O_2]^3}{[O_3]^2}$ | BOTH correct. | | |
| THREE (a)<br>(b) | $\rightarrow NH_3(aq) + H_3O^+(aq)$<br>$\rightarrow F^-(aq) + H_3O^+(aq)$ | BOTH correct. (States may be omitted.) | | |

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<tr>
<td>FOUR<br>(a)<br><br><br><br><br>(b)</td>
<td>0.00112 $mol\ L^{-1}$ HCl solution<br>
<table>
<tr><td>$[H_3O^+]$ ($mol\ L^{-1}$)</td><td>$[OH^-]$ ($mol\ L^{-1}$)</td><td>pH</td></tr>
<tr><td>0.00112</td><td>$8.93 \times 10^{-12}$</td><td>2.95</td></tr>
</table>
<br>
$3.68 \times 10^{-2}$ $mol\ L^{-1}$ NaOH solution<br>
<table>
<tr><td>$[H_3O^+]$ ($mol\ L^{-1}$)</td><td>$[OH^-]$ ($mol\ L^{-1}$)</td><td>pH</td></tr>
<tr><td>$2.72 \times 10^{-13}$</td><td>$3.68 \times 10^{-2}$</td><td>12.6</td></tr>
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</td>
<td>Calculate correctly<br>(a) $[H_3O]^+$ and pH<br>(b) $[OH^-]$</td>
<td>Use $K_w$ or pOH to calculate<br>(a) $[OH^-]$<br>(b) $[H_3O]^+$ and pH<br>ie, all calculations are correct.<br><br>(Ignore rounding – unless they are making numbers up or careless with use of numbers i.e. $[OH^-]$ or transposing numbers.)</td>
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<td>FIVE</td>
<td>$n(C_2H_5OH) = \frac{18.4}{46.0} = 0.400$ mol<br><br>1 mol releases $\frac{546}{0.400}$ = 1365 $kJ\ mol^{-1}$<br>0.400<br><br>$\Delta H = -1365\ kJ\ mol^{-1}$</td>
<td>One step correct<br>OR<br>units incorrect.</td>
<td>Answer correct.<br>with negative sign or energy released stated.<br><br>Units correctly stated.<br><br>(If $\Delta_r H$ is written as positive or without correct units, even if written statement is correct, this negates so will result in A).</td>
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| SIX (a)(i) | The forward reaction is exothermic. A decrease in temperature causes an equilibrium shift to favour reaction that releases energy, ie shift in the exothermic direction. So to have a greater amount of $SO_3(g)$ in the equilibrium mixture, the temperature must be low. | Recognises low temperature favours exothermic reaction.<br>OR<br>recognises that at a lower temperature, the rate of reaction is slower. | Explanation of<br>EITHER<br>a decrease in temperature causes an equilibrium shift to favour reaction in the exothermic direction. So at a low temperature, equilibrium shift favours $SO_3(g)$.<br>OR<br>at a low temperature, the equilibrium shift produces more $SO_3(g)$ but takes a long time to reach equilibrium. | EITHER<br>Explanation of a decrease in temperature causes an equilibrium shift to favour reaction in the exothermic direction. So at a low temperature, equilibrium shift favours $SO_3(g)$<br>AND<br>(ii) related to reaction rate (slower at lower temperature)<br>OR<br>at a low temperature, the equilibrium shift produces more $SO_3(g)$ but takes a long time to reach equilibrium.<br>450°C is a compromise temperature producing a sufficiently high proportion of sulfur trioxide in the equilibrium mixture, but in a short time. |
| (ii) | The lower the temperature used, the slower the reaction rate.<br>Although a greater amount of $SO_3(g)$ will be present in the equilibrium mixture, it will be uneconomical if it takes a long time for the reaction to reach that equilibrium.<br>Approximately 450°C is a compromise temperature producing a sufficiently high proportion of sulfur trioxide in the equilibrium mixture, but in a short time. | | | |
| (b)(i) | Use a high pressure / decreasing volume. | Correct method. | Correct method with reason. | |
| (ii) | High pressure / decreasing volume<br>There are 3 **gaseous** moles / molecules on the left-hand side of the equation, but only 2 moles / molecules on the right.<br>If the pressure is increased, the system will move to minimise the effect of this and favour the reaction that produces fewer molecules of **gas**, since that will cause the pressure to fall again, ie, will favour formation of $SO_3(g)$. | | | |

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| SEVEN | Fizziness<br>As the lid is opened, $CO_2(g)$ escapes from the drink and the **pressure** is decreased. The equilibrium in **Equation One** will shift to the left. The position of equilibrium moves to minimise the effect of the change.<br>Ie, the decrease in **pressure** favours formation of more moles / molecules of gas, so the position of equilibrium will move to favour formation of more $CO_2(g)$ in Equation One.<br>This results in a lower concentration of $CO_2(aq)$. As more $CO_2(aq)$ is lost from the drink, there is less fizz in the drink.<br><br>pH<br>As the concentration of $CO_2(aq)$ is decreased, the position of equilibrium in **Equation Two** will shift to favour formation of reactants, ie form more $CO_2(aq)$.<br>As this occurs, the concentration of $H_3O^+$ (and $HCO_3^-$) ions decreases. As the $[H_3O^+]$ decreases, the pH will increase. | Description of ONE change with partial explanation.<br>Eg, loss of $CO_2$ causes first equilibrium to move to left but no reference to change in pressure or concentration of $CO_2$.<br><br>Allow a follow on error if Equation 1 is incorrectly used. | ONE change explained using equilibrium principles. | Discusses BOTH changes including for each:<br>• effect on equilibrium<br>• effect on concentration/ amount (can be implied)<br>• link to fizziness and pH. |
| EIGHT<br>(a)(i)<br>(ii) | **HB** is circled<br>The strength of an acid is a measure of its ability to donate hydrogen ions.<br>Both acids react with water and donate $H^+$ ions to water.<br>$HA(aq) + H_2O \leftrightarrows H_3O^+(aq) + A^-(aq)$<br>$HB(aq) + H_2O \leftrightarrows H_3O^+(aq) + B^-(aq)$<br>OR<br>$[H_3O^+]$ from HA = $10^{-3.5} = 3.16 \times 10^{-4}$ mol $L^{-1}$.<br>$[H_3O^+]$ from HB = $10^{-1.8} = 1.58 \times 10^{-2}$ mol $L^{-1}$.<br><br>The lower pH of acid HB means there is a higher concentration of $H_3O^+$ ions in the solution. As the acids are of the same concentration, the position of equilibrium lies further to the right for this acid. Thus more $H^+$ ions have been donated to water making HB a stronger acid. | HB identified and recognition of acid strength related to ability to donate $H^+$ ions, or more $H^+$ is present in the resulting solution / dissociation.<br><br>(NOT pH since this is restating the question). | HB identified, acid strength related to ability to donate $H^+$ ions, including<br>EITHER, equation<br>OR<br>reference to same concentration.<br><br>MAY incorrectly state HB dissociates fully (ie does not negate). | |

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| EIGHT (b)(i) | Bubbles of gas are produced with both acids but this is more vigorous with HB.<br>Increase in temperature is noted in this reaction, and more heat is immediately produced by HB reaction.<br>Magnesium disappears/dissolves/consumed with both acids but in less time with HB. | An observation correct for ONE test.<br>(See underlined.)<br><br>Allow follow on error from 8(a). Ie, if HA was identified as the stronger acid. (Achievement only). | An observation correct and recognises the reaction is faster due to more $H_3O^+$ immediately available in HB. | Discussing one reaction<br>• Observation correct,<br>AND, either<br>• rate dependent on $[H_3O^+]$<br>OR<br>• *V*(NaOH) dependent on *n*(acid),<br>AND<br>• equations. |
| (ii) | There is no (visual) change, but both acids require the same volume of sodium hydroxide to completely react.<br>Increase in temperature is noted in this reaction, and more heat is immediately produced by HB reaction. | | | |
| (c) | Both acids react with magnesium as the reaction occurs between Mg and $H_3O^+(aq)$ ions.<br>$Mg + 2H_3O^+ \rightarrow Mg^{2+} + H_2(g) + 2H_2O$<br>OR $Mg + 2H^+ \rightarrow Mg^{2+} + H_2(g)$<br>Since $H_2$ gas is produced, bubbles are observed in each reaction. (The same volume of gas is produced with both acids, as the volume and concentration are the same). As $[H_3O^+(aq)]$ at equilibrium is greater in HB, there is increased collision rate with the Mg and so the reaction rate is increased, and the bubbles are formed more rapidly. As the reaction in HB is faster, the magnesium disappears in a shorter period of time.<br>The total amount of $H_3O^+(aq)$ ions available in each acid is the same, as the volume and concentration is the same. This means the volume of sodium hydroxide required to completely react with the acid will be the same.<br>$H_3O^+ + OH^- \rightarrow 2H_2O$<br>OR $H^+ + OH^- \rightarrow H_2O$ | | | |

## Judgement Statement

| Achievement | Achievement with Merit | Achievement with Excellence |
|---|---|---|
| Total of SEVEN opportunities answered at Achievement level or higher<br><br>7 × A | Total of at least SEVEN opportunities answered with FIVE at Merit level or higher<br><br>5 × M + 2 × A | Total of at least SEVEN opportunities answered with TWO at Excellence level and THREE at Merit level or higher<br><br>2 × E + 3 × M + 2 × A |