Assessment Schedule – 2016

Chemistry: Demonstrate understanding of chemical reactivity (91166)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Initially the rate of the reaction is fast, as shown by the steepness of Part A in the graph. This is because the concentrations of the reactants, Mg and HCl, are at their highest, resulting in a high frequency of effective collisions, so the rate of reaction is highest there. As time proceeds, the reactants are forming the products $MgCl_2$ and H_2 gas, so the concentration of the reactants decreases, resulting in fewer reactant particles available to react. This results in a decrease in the frequency of effective collisions between reacting particles and a decrease in the production of H_2 gas, as shown in Part B of the graph where the gradient of the graph becomes less steep. Consequently, the rate of reaction decreases. Once all of one reactant (or both) has been used up, the reaction will stop, so no H_2 gas is produced, as shown on the graph in Part C as a horizontal line.	• Describes the rate of the reaction for one stage of the reaction (fast, decreases, stops). • Describes the relative concentrations of the reactants for one stage of the reaction (highest, decreasing, used up).	• Explains the rate of reaction for TWO parts of the reaction in terms of reactant concentration and collision theory (must refer to frequency of collisions or collisions per second for at least one part).	
(b)	In the reaction of hydrochloric acid with Mg ribbon and Mg powder, both form the same products, magnesium chloride and hydrogen gas. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ However, since Mg powder has a larger surface area than Mg ribbon, the powder will have more Mg particles immediately available to collide, there will be more effective collisions per second and more H_2 gas will be produced initially, resulting in a faster rate of reaction. Mg ribbon will take longer to react because fewer particles are immediately available to collide, so will have a slower rate of reaction. Both reactions will eventually produce the same volume of hydrogen gas as the same amounts of each reactant are used.	• Describes the different surface areas in each reaction. OR Describes the rate of reaction / production of the $H_2(g)$ for each reaction.	• Explains the rate of both reactions in terms of surface area of Mg and collision theory (must refer to frequency of collisions or collisions per second for at least one part).	• Compares and contrasts both reactions with reference to surface area, overall volume of $H_2(g)$ produced, collision theory, and rates of reaction ideas. (*Must 'compare and contrast' to get E.*)

(c)	MnO_2 is a catalyst. MnO_2 provides an alternative pathway with lower activation energy for the decomposition of H_2O_2. Therefore, (*) more reacting particles will collide with sufficient energy, resulting in a higher frequency of successful collisions; resulting in an increase in the rate of reaction. (Only a small amount of MnO_2 is required because catalysts are not used up in this reaction.)	• Identifies MnO_2 as a catalyst. OR The catalyst provides an alternative pathway for this reaction. OR The catalyst is not used up. OR Lower activation energy is needed.	• Explains an increased rate of reaction by a catalyst, since an alternative pathway and lowered activation energy is provided.	• Relates alternate pathway to lowered activation energy, more effective collisions, and increased rate of reaction (must include 'more reacting particles will collide with sufficient energy', see *).

NØ	**N1**	**N2**	**A3**	**A4**	**M5**	**M6**	**E7**	**E8**
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e (minor error / omission allowed, e.g. alternate pathway omitted for (c))	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	$H_2O(\ell) + NH_3(aq) \rightleftharpoons OH^-(aq) + NH_4^+(aq)$ $H_2O(\ell) + NH_4^+(aq) \rightleftharpoons H_3O^+(aq) + NH_3(aq)$	• Products in one reaction correct.		
(b)	When sodium carbonate dissolves in water, it dissociates into ions. EQUATION ONE: $Na_2CO_3(s) \rightarrow 2Na^+(aq) + CO_3^{2-}(aq)$ The carbonate ions then react in water. EQUATION TWO: $CO_3^{2-}(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$ The OH^- ions produced make this a basic (alkaline) solution.	• Writes a correct dissociation equation (ONE or TWO). OR Identifies Na_2CO_3 as a basic solution since OH^- produced / accepts a proton / cannot donate a proton.	• Links basic nature of CO_3^{2-} to its ability to produce OH^- ions in solution, with equation TWO correct. (*States not required.*)	
(c)(i) (ii)	$pH = -\log[H_3O^+] = -\log 0.0341 = 1.47$ $[H_3O^+] = 10^{-pH} = 10^{-12.4} = 3.98 \times 10^{-13}$ mol L^{-1} $\left[OH^-\right] = \frac{K_w}{\left[H_3O^+\right]} = 0.0251 \text{ mol L}^{-1}$ OR pH + pOH = 14 so pOH = 14 – 12.4 = 1.6 $[OH^-] = 10^{-pOH} = 10^{-1.6}$ = 0.0251 mol L^{-1}	• pH calculated correctly for (i). • Calculates $[H_3O^+]$ OR $[OH^-]$ for (ii).	• Calculates $[H_3O^+]$ AND $[OH^-]$ for (ii).	• All calculations correct for (c) with correct units. (accept 2-4 sig. fig.)

(d)(i)	pH reflects the concentration of H_3O^+ ions. The higher the pH, the lower the $[H_3O^+]$. Both ammonium ions, NH_4^+, and propanoic acid are weak acids, so both only partially dissociate in water and produce fewer H_3O^+ ions in water than HCl, which is a strong acid. As a strong acid, HCl completely dissociates in water, resulting in a high concentration of H^+ (H_3O^+) ions and a low pH. $NH_4^+(aq) + H_2O(\ell) \rightleftharpoons NH_3(aq) + H_3O^+(aq$ $C_2H_5COOH(aq) + H_2O(\ell) \rightleftharpoons C_2H_5COO^-(aq) + H_3O^+(aq)$ $HCl(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + Cl^-(aq)$ NH_4^+ has a higher pH than propanoic acid, which means that it has a lower $[H_3O^+]$ in solution.	• Recognises that pH is a measurement of the concentration of H^+ / H_3O^+ ions OR Recognises degree of dissociation for two solutions.	• Explains differences in pH in terms of concentration of H^+ / H_3O^+ ions for two solutions.	• Relates the pH for EACH solution in terms of the degree of dissociation in water and $[H_3O^+]$ / $[H^+]$, plus at least TWO correct equations.
(ii)	Charged particles that are free to move are needed to conduct electricity. Ammonium chloride is a good conductor of electricity because it is a salt that will completely dissolve / dissociate / ionise in water, releasing its ions NH_4^+ and Cl^- into solution, i.e. relatively high concentration of ions. Propanoic acid is a weak acid, so will only partially dissociate (ionise) in water to form a relatively small proportion of ions, resulting in it being a poor conductor of electricity. ($NH_4Cl(s) \overset{H_2O}{\rightleftharpoons} NH_4^+(aq) + Cl^-(aq)$ $CH_3CH_2COOH(aq) + H_2O(\ell) \rightleftharpoons CH_3CH_2COO^-(aq) + H_3O^+(aq)$)	• Recognises that charged particles (not electrons) that are free to move are required for electrical conductivity.	• Explains conductivity by linking degree of dissociation to proportion of ions (not electrons) present for ONE solution.	• Relates conductivity for BOTH solutions to the degree of dissociation in water and the relative amounts of all ions (not just 'charged particles' or H_3O^+) in solution. *Equations not required.*

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No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e	3e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$CO + 2H_2 \rightleftharpoons CH_3OH$	• Correct equation, with equilibrium arrow.		
(b)	The value of K_w at 1×10^{-14} is very small, which means that very little water has ionised / dissociated because there is very little product (i.e. very few ions).	• Identifies there is little dissociation in water.	• Links magnitude of K_w value to the degree of ionisation / dissociation and amount of product / reactant.	
(c)(i) (ii)	Adding dilute acid increases the concentration of the acid, so the reaction moves in the forward direction / favours the products to use up the added acid, so the colour of the solution will become more orange. Adding base means that acid that reacts with the base is removed from the equilibrium / concentration of the acid decreases. This will drive the equilibrium in the backwards direction / favours the reactants to replace the H^+ used up, causing the solution to become more yellow in colour. May include the equation $H^+ + OH^- \rightarrow H_2O$ in their answer.	• One correct colour / direction identified.	• Explains the shift in equilibrium position for ONE reaction in terms of equilibrium principles, e.g. (i) [acid] increased, so equilibrium moves towards products, turns orange / (ii) [acid] decreased, so equilibrium moves towards reactants, turns yellow.	• Analyses ONE reaction to explain the shift in equilibrium position in terms of equilibrium principles. ((i) 'use up added acid' OR (ii) 'acid removed to react with base').

(d)(i)	$64 = \frac{[\mathrm{HI}]^2}{0.312 \times 0.312}$ $[\mathrm{HI}] = \sqrt{64 \times 0.312^2} = 2.50 \text{ mol L}^{-1}$	• One correct step of the calculation (correct substitution).	• Calculates correct concentration of HI with unit (accept 2-4 sig. figs).	
(ii)	There would be no effect on the equilibrium if pressure was increased because there are equal numbers of moles of gas on either side of the equilibrium / in the reactants and products.	• Recognises change in pressure has no effect.	• Explains effect of pressure in terms of moles of **gaseous** particles.	
(iii)	(Temperature is the only factor that can change the *K* value of an equilibrium). When the temperature increases, the reaction moves in the endothermic direction to absorb the added heat. In this reaction, the value of *K* decreased, indicating the ratio of products to reactants (numerator to denominator) decreased. Since there will be fewer products and more reactants, adding heat is favouring the backwards reaction. Therefore, the forward reaction is exothermic.	• Identifies increase in temperature favours the endothermic reaction.	• Links decrease in K_c value to changes in the relative concentrations of reactants or products.	• Justifies the forward reaction as exothermic by explaining how the increase in temperature favours the endothermic reaction, and the decreasing K_c value results in a change in relative concentrations of reactants or products.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e (minor error / omission allowed in (d) (iii))	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 13	14 – 18	19 – 24