Assessment Schedule – 2021

Chemistry: Demonstrate understanding of chemical reactivity (91166)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i) (ii)	The CO_2 is released from the flask. At the start of the reaction, the amount of the reactants, $CaCO_3$ and HCl, are at their highest, resulting in a high frequency of effective collisions. $CaCO_3$ and HCl are being converted to H_2O and CO_2 and as the CO_2 leaves the flask, the mass decreases quickly meaning a high rate of reaction. As the reaction continues, the amount of the reactants decreases because products are forming, meaning that fewer reactant particles are available to react. This results in a decrease in the frequency of effective collisions between reacting particles, so the mass decreases less quickly meaning a lower rate of reaction.	• Correct answer. • Describes the rate of the reaction for one stage of the reaction. • Describes how the relative amounts of the reactants changes.	• Explains the rate of reaction for TWO parts of the reaction in terms of reactant amount and in turn frequency of collisions	
(b)	Calcium carbonate powder has a larger surface area than calcium carbonate chips, so the powder will have more particles immediately available to collide. Hence, there will be more effective / successful collisions per second, resulting in a faster rate of reaction. Calcium carbonate chips 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 reduction in mass as the same mass of carbon dioxide is formed, because the same amounts of each reactant are used.	• Describes the different surface areas in each reaction. OR Describes the rate of reaction / Same loss of mass for each reaction.	• Explains the rate of both reactions in terms of surface area / particles exposed of calcium carbonate leading to more / less frequent collisions.	• Compares and contrasts both reactions with reference to increasing surface area, leading to more particles available to react giving more frequent collisions and therefore a faster rate with the presence of the same amount of reactants leads to the same total mass loss.
(c)(i) (ii)	KI is a catalyst. KI provides an alternative pathway with lower activation energy for the decomposition of H_2O_2. Therefore, more reacting particles will collide with sufficient energy to overcome activation energy, resulting in a higher frequency of successful collisions, resulting in an increase in the rate of reaction.	• Identifies KI as a catalyst. AND Recognises the catalyst provides an alternative pathway for this reaction / lowers activation energy.	• Links the increased rate of reaction to the lower activation energy due to alternative pathway provided by the catalyst.	• Relates alternate pathway to lowered activation energy leading to more collisions exceeding activation energy, more frequent effective collisions, and increased rate of reaction.

Note: in all cases 'per unit time' can be used in place of frequency, as can collision rate / rate of collisions and collide more often.

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

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$	• Correct equation, with equilibrium arrow. (State symbols not required.)		
(b)(i) (ii)	$\frac{0.989^2}{0.0102^2 \times 0.0128} = 734\,484 = 734\,000\ (3\text{sf})$ This value is higher than K_c (this value is not the same as K_c). As K_c is ratio of products / reactants, to decrease the value of K_c the concentration of reactants would need to increase / concentration of products would need to decrease. To increase the reactants, the reverse reaction would need to be favoured.	• Correct substitution. (no +) OR Identifies calculated value is not the same as Kc value. (based on incorrect calculation) • Correct direction based on answer to (b)(i).	• Calculation correct. (ignore units and SF) AND States the calculated value is not the same as Kc and therefore not at equilibrium OR states the calculated value is > Kc therefore needs to go in the reverse direction.	• Full justification. Correct calculation (correct units and 3.s.f), and discussion that indicates Qc>Kc and therefore the reverse direction is favoured. May discuss the ratio of Products to reactants being to high and therefore favouring the reverse direction instead.
(c)(i) (ii)	Adding CH_3COOH increases the concentration of CH_3COOH in the system, so the reaction minimises this change by moving in the forward direction / favours the products to use up the added CH_3COOH. Adding NaOH reacts with H_3O^+, removing it from the system. This will drive the equilibrium in the forward direction / favours the products to replace the H_3O^+ to restore equilibrium.	• One correct direction identified. (i or ii)	• Explains the shift in equilibrium position for ONE situation in terms of equilibrium principles.	• BOTH shifts in equilibrium position in terms of equilibrium principles are explained.
(iii)	When temperature increases, the reaction moves in the endothermic direction to absorb the added heat. In this reaction, the value of K_c increases, indicating the ratio of products to reactants increases. Since there will be fewer reactants and more products, the equilibrium is favouring the products, so adding heat favours the forward reaction / the position of equilibrium shifts right. Hence, the forward reaction, is endothermic. (Temperature is the only factor that can change the K_c value in an equilibrium.)	• Identifies that a temperature increase shifts equilibrium in endothermic direction. OR Recognises increased K_c value indicates forward reaction favoured / more product formed.	• Explains that with increasing temperature equilibrium will absorb the added heat energy and therefore will favour the endothermic reaction. OR Links the increase in K_c value to increased products to reactants which indicates the forward direction is favoured	• Justifies forward direction as endothermic by linking the effect of increasing temperature to the change in K_c value and relative amounts of reactants / products

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e	3e

Q	**Evidence**	**Achievement**	**Merit**	**Excellence**
THREE (a)	$HCO_3^- + H_2O \rightleftharpoons H_3O^+ + CO_3^{2-}$ $HCO_3^- + H_2O \rightleftharpoons OH^- + H_2CO_3$	• Products in one reaction correct.		
(b)(i)	$pH = -\log[H_3O^+]$ $= -\log 0.0625$ $= 1.20$	• pH calculated correctly for (i).	• Both calculations correct with correct units where appropriate. (ignore sf).	
(ii)	$[H_3O^+] = 10^{-9.5} = 3.16 \times 10^{-10}$ $[OH^-] = \dfrac{1\times10^{-14}}{3.16\times10^{-10}}$ $= 3.16 \times 10^{-5}$ mol L^{-1}	• One step correct for (ii).		
(c)	pH reflects the concentration of H_3O^+ ions. The higher the pH, the lower the $[H_3O^+]$. Potassium hydroxide and methylamine are bases, releasing OH^- in solution. The higher the $[OH^-]$ in solution, the lower the $[H_3O^+]$ and the higher the pH. CH_3NH_2 is a weak base, so only partially dissociates / ionises in water, giving a lower $[OH^-]$ than KOH, which is a strong base and completely dissociates / ionises in water, resulting in a high concentration of $[OH^-]$. $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$ $KOH \rightarrow K^+ + OH^-$ Methanoic acid is a weak acid that partially dissociates to form H_3O^+ in solution; hence $[H_3O^+] > [OH^-]$, and pH is less than 7. $HCOOH + H_2O \rightleftharpoons HCOOH^- + H_3O^+$	• Recognises that pH is a measurement of the concentration of H_3O^+ ions. (e.g. correctly calculates $[H_3O^+]$ from pH.) OR Recognises degree of dissociation / ionisation for two solutions. OR Recognises that increased $[OH^-]$ means decreased $[H_3O^+]$ or vice versa. OR 1 equation correct.	• Explains differences in pH for two solutions. OR Discusses the dissociation of two solutions with equations.	• Relates the pH for EACH solution in terms of the degree of dissociation / ionisation in water and $[H_3O^+]$ and $[OH^-]$ with 2 correct equations. (i.e. strong / weak therefore complete / partial dissociation therefore high / moderate $[OH^-]$ / $[H_3O^+]$ therefore pH with 2 correct equations).

(d)	In order to conduct, a substance must have free-moving charged particles. Dissolved ions are responsible for the conductivity of solutions. HCl is a strong acid and NH_4Cl is a salt. They are good conductors of electricity because they completely dissociate / ionise in water, resulting in a relatively high concentration of ions in solution. $HCl + H_2O \rightarrow H_3O^+ + Cl^-$ $NH_4Cl \rightarrow NH_4^+ + Cl^-$ Whereas ammonia is a weak base, so only partially dissociates / ionises in water, forming a lower concentration of ions, resulting in poor electrical conductivity. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$	• Recognises that ions in solution (or free moving charged particles) are required for electrical conductivity. OR Links conductivity to dissociation / ionisation for ONE solution. • One equation correct.	• Explains conductivity by linking degree of dissociation / ionisation to amount of ions (or free moving charged particles) present for TWO solutions.	• Relates conductivity for ALL solutions to the degree of dissociation / ionisation in water and the relative amounts of all ions in solution with 2 correct equations. (must link conductivity to ions / free moving charged particles).

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

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 13	14 – 18	19 – 24