Assessment Schedule – 2025

Chemistry: Demonstrate understanding of chemical reactivity (91166)

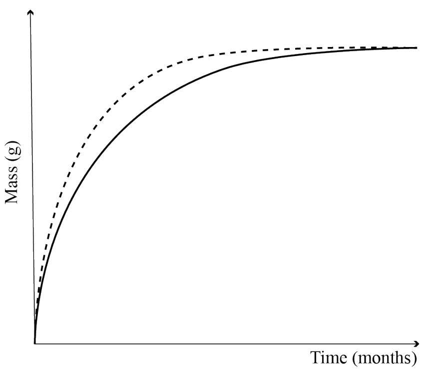
Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i)	$K_c = \frac{[HCO_3^-][H_3O^+]}{[H_2CO_3]}$	• Correct K_c expression.		
(ii)	K_c is the concentration of products divided by the concentration of reactants. A value of K_c that is much smaller than 1 indicates there are far more reactants than products. This shows that the reverse reaction is favoured.	• A correct statement about the magnitude of K_c OR the method of calculating K_c.	• Explains the ratio of products to reactants. AND Identifies that the reaction must favour reactants / reverse reaction.	
(iii)	The enthalpy of the reaction is a negative value, showing the forward reaction is exothermic. This means the reverse must be endothemic. Increasing the temperature will favour the endothermic reaction, so the reverse reaction is favoured. K_c is affected by temperature, so by favouring the reverse reaction, K_c will get smaller, and therefore more reactants will be produced.	• Identifies that increasing temperature will favour the endothermic reaction. OR Identifies that K_c will be affected by temperature. OR Identifies that more products are being made.	• Identifies that the reverse reaction is favoured to absorb the added heat / minimise the change (restore equilibrium)). OR Explains that the K_c decrease shows reactants favoured when temp is increased).	• Fully describes the effect of temperature on the forward and reverse reactions, and explains the change in K_c linked to more products being produced.

(b)(i)	$pH = -\log_{10}[H_3O^+]$ $pH = -\log(0.25)$ $pH = 0.602$	• Correct value.		
(ii)	$[H_3O^+] = 10^{-pH} = 0.050 \text{ mol L}^{-1}$ $K_w = 1 \times 10^{-14} = [OH^-][H_3O^+]$ $[OH^-] = 2.00 \times 10^{-13} \text{ mol L}^{-1}$	• One step correct.	• Correct answer with correct units and 2–4 sf (use of pOH is acceptable).	
(iii)	Weak acids dissociate partially in water, while strong acids dissociate completely into their constituent ions. Both are able to donate a proton, acting as an acid. pH is a measure of the concentration of H_3O^+ ions in solution, and the value for pH gets lower the higher this concentration is. The weak acid, carbonic acid, will have a pH that is greater than the pH of the strong acid because it does not completely dissociate to give H_3O^+, while the strong acid will. $H_2CO_3 + H_2O \rightleftharpoons HCO_3^- + H_3O^+$ $HCl + H_2O \rightarrow Cl^- + H_3O^+$ In order to conduct electricity, a material needs to have freely moving charged particles. Because the strong hydrochloric acid dissociates completely into its ions, it will be able to conduct electricity. The weak carbonic acid does not completely dissociate, so will have far fewer ions to conduct the flow of electricity. This means hydrochloric acid is more conductive than carbonic acid.	• Identifies that strong acids completely dissociate, while weak acids partially dissociate. • Defines pH. OR Defines conductivity.	Explains the pH in relation to dissociation for both solutions. • Explains the conductivity of both solutions in relation to dissociation.	• Justifies both properties (pH and conductivity) relative to each other with explanation and relevant equations.

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

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i)	The shells will slowly lose mass (become thinner), and bubbles will form as the carbonate reacts to form carbon dioxide.	• Identifies that mass / thickness will be lost OR bubbles form OR surface becomes rougher / more pitted.		
(ii)	Shell B will be more vulnerable. This is because the surface area of Shell B is much greater, so more particles are exposed to the acidic surroundings. Collision theory states that in order for a reaction to be successful, the particles must collide with sufficient energy and in the correct orientation. The rate of a reaction is the number of successful collisions per unit time. A greater surface area with more particles exposed means there are more particles of calcium carbonate able to collide with the acid. This means more collisions will occur every second, therefore more successful collisions occur every second, and the rate of reaction is increased. Shell B will react faster.	• Identifies Shell B as having a greater surface area. OR Identifies rate of reaction increases with surface area.	• Full explanation.	

(b)(i)		• Second line shows faster rate (above first line).		
(ii)	Catalysts increase the rate of a reaction. The catalyst, carbonic anhydrase, provides an alternative pathway to the reaction to form shells. This alternative pathway has a lower activation energy (the minimum energy required for a collision to result in a reaction) meaning that particles do not need to collide with as much energy as the uncatalysed pathway in order to result in a successful reaction. This means a greater proportion of collisions will now occur with sufficient energy to overcome the lower activation energy requirement. Therefore, there are now more successful collisions per second, which results in a higher rate of reaction and faster formation of shells.	• Identifies that a catalyst increases rate of reaction. OR Basic definition of a catalyst (lowers activation energy and provides an alternative pathway).	• Links the higher rate of reaction to the lower activation energy requirement and the catalyst providing the alternative pathway.	• Relates alternative pathway to lower activation energy, frequency of successful collision, and rate of reaction.

(c)(i)	$Ca(OH)_2(s) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$ $CaCl_2(s) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq)$ $Ca(CH_3COO^-)_2(s) \rightarrow Ca^{2+}(aq) + 2CH_3COO^-(aq)$	• Two correct equations.		
(ii)	$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$	• Identifies that the reaction of ethanoate occurs with water.	• Correct equation in (ii), including arrow. OR	
(iii)	Acids can donate protons, while bases can accept them. pH is a measure of the hydronium ions / protons concentration in solution. The higher the $[H_3O^+]$ concentration, the lower the pH value, the more acidic the compound. Bases have a very low concentration of H_3O^+, so their pH is greater than 7. Calcium hydroxide fully dissociates to give hydroxide ions, which is a strong base and can accept protons from solution. Its pH would be the highest, at 12–14. Calcium chloride dissociates into ions, which cannot accept nor donate a proton, so will have a pH of 7. Although calcium ethanoate forms the ethanoate ion when it dissociates, which can accept a proton to form the weak acid, ethanoic acid, the presence of the OH^- ions also produced make it basic in solution. Its pH will be greater than 7.	• Recognises the nature of TWO of the three solutions OR Definition for an acid and base.	Explains in (iii) how calcium ethanoate acts as a basic salt. • Explains that bases accept protons so hydroxide is a base. OR Recognises that $CaCl_2$ fully dissociates and no proton transfer occurs.	• Fully discusses the differences in compound pH by defining acid and base, explaining how proton transfer is linked to pH, and justifying the pH of two compounds including calcium ethanoate.

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

Q	Evidence	Achievement	Merit	Excellence
THREE (a)(i)	Removing the product PCl_5 will result in the equilibrium shifting to offset the change / replace the lost product. This means the forward reaction will be favoured to increase the concentration of PCl_5, decreasing slightly the concentration of the reactants Cl_2 and PCl_3.	• Identifies forward is favoured / products favoured.	• Correct explanation.	
(ii)	Decreasing the volume of the reaction vessel increases the pressure. Increasing the pressure will favour the side of the reaction that produces the fewest moles of gas. In this case, the reactants have two moles of gas for every one mole of the product; therefore the forward reaction producing PCl_5 is favoured.	Explains why the pressure has increased. OR Identifies forward is favoured / products favoured.	• Identifies pressure favours fewest moles. OR Why the forward is favoured.	• Fully explains equilibrium principles of pressure increase, and moles of gas linked to equation, justifying favouring production of $PC1_5$.
(b)(i)	$K_c = 0.387$	• Correct value.		
(ii)	The increase in concentration favours the forward reaction. The equilibrium constant will not change, as K_c is not affected by concentration.	• Identifies forward is favoured.	• Explains no change to K_c.	
(iii)	Condition 1 would be better as the K_c value is larger, indicating the system favours the products, and therefore giving a greater amount of PCl_5. The value for Condition 2 is lower, indicating fewer products, which makes it harder to produce the desired product.	• Identifies Condition 1.	• Explains why Condition 1 is better.	
(iv)	Condition 1: $[PCl_5] = 0.53$ mol L^{-1} Condition 2: $[PCl_5] = 0.00041$ mol L^{-1}	• One with correct process with minor error.	• Two concentrations correct.	

(c)	The forward reaction must be exothermic, as increasing the temperature favours the endothermic reaction / decreasing the temperature favours exothermic. This is because the endothermic reaction can consume the extra heat energy / exothermic will produce energy to replace the decrease, due to temperature change. This means the higher temperature will be a disadvantage because it disfavours the forward reaction, lowering the amount of product. Because the reverse is favoured, the amount of the product present will be lowered by increased temperature. However, temperature also increases the rate of reaction. The more successful collisions there are per second, the faster the reaction rate. Increasing temperature means the particles are moving with more kinetic energy. More collisions will now occur per second, as they collide more often, and the collisions will occur with more energy, resulting in more collisions occurring with energy greater than the activation energy for the reaction. This means more successful collisions occur per second, increasing rate of reaction. A faster rate of reaction will result in a better production of the desired product, even if the equilibrium reaction favours the starting materials.	• Identifies forward reaction as exothermic. OR Describes particles as moving faster / have more kinetic energy when temperature is higher.	• Explains how temperature affects rate of reaction. • Explains that the forward reaction is exothermic so is disfavoured by increasing temperature.	• Full explanation, including the balance of increased temperature favouring the reverse reaction as a disadvantage.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	4m	5m	1e	2e (may include minor error in one part)

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 8	9 – 13	14 – 18	19 – 24