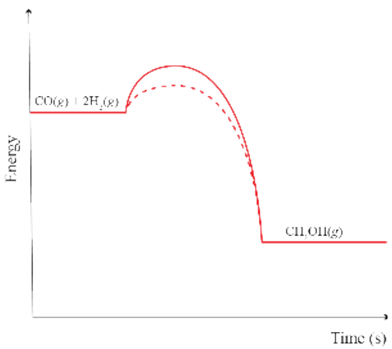
Final Assessment Schedule – 2022

Chemistry: Demonstrate understanding of chemical reactivity (91166)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i)	$K_c = \frac{[HI]^2}{[H_2][I_2]}$	• Correct K_c expression.		
(ii)	$K_c = \frac{0.711^2}{0.105 \times 0.105} = 45.9$	• Correct calculation from incorrect K_c.	• Correct answer.	
(iii)	When the temperature is increased, the system responds to minimise the effect of the change by favouring the endothermic reaction. As the forwards reaction is endothermic, the equilibrium shifts to the right. This increases the concentration of the products (decreases the concentration of the reactants). As K_c is the ratio of products / reactants, this results in an increase in K_c.	• Recognises endothermic reaction favoured. • Recognises equilibrium shifts to the right.	• Links the favouring of the endothermic reaction to direction of equilibrium shift. OR Links direction of equilibrium shift to change in K_c value.	• Change to K_c fully justified.
(b)(i)	$HI(g) + H_2O(l) \rightarrow H_3O^+(aq) + I^-(aq)$ $HF(g) + H_2O(l) \rightleftharpoons H_3O^+(aq) + F^-(aq)$	• Both equations correct with correct arrows.		
(ii)	As HI is a strong acid, it fully dissociates into ions, while HF only partially dissociates, as it is a weak acid. This means HI has a higher concentration of H_3O^+ ions in solution than HF, thereby giving it a lower pH value. As electrical conductivity is dependent upon the total concentration of ions in solution, the solution of hydrogen iodide is a better conductor of electricity, due to the higher total concentration of ions.	• Identifies full dissociation of HI and partial dissociation of HF. • Identifies conductivity depends upon ion concentration. OR Identifies pH depends upon $[H_3O^+]$.	• Links degree of dissociation to $[H_3O^+]$ for ONE substance. • Links concentration of ions in solution to conductivity for ONE substance.	• Full explanation of greater acidity and conductivity of HI.

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

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i)	The concentrations of all species are constant. This means the rate of the forward reaction equals that of the reverse reaction, and the system is at equilibrium.	• Identifies the concentrations of all species are constant.	• Links constant concentration to equal rates of reaction.	
(ii)	When CO is added, the system responds by shifting to the right to minimise the effect of the change. This means the forwards reaction is favoured, decreasing the concentration of the reactants and increasing the concentration of the products. This is seen in the graph, as the concentration of both H_2 and CO decrease following the initial addition of CO, while the concentration of CH_3OH is increased. The forwards reaction is favoured until equilibrium is re-established, as shown in the graph when the concentrations no longer change / become constant.	• Identifies the forwards reaction is favoured / equilibrium shifts right. • Recognises that equilibrium is re-established.	• Links favouring of forwards reaction to the decrease of reactants / increase in products shown in the graph.	• Full explanation with reference to equilibrium principles and the relative concentrations of species on the graph.
(iii)	There are three moles of gas on the reactants side of the equation, and 1 mole of gas on the products. When the pressure is increased, the system opposes the change by favouring the side of the equilibrium with the least number of gas moles. This means the equilibrium shifts to the right / favours the forwards reaction, producing a greater amount of methanol.	• Recognises an increase of pressure favours the side with fewer gas particles.	• Links increase in pressure to shift in equilibrium with reference to number of gas moles in equation.	• Fully explains how increasing pressure increases methanol production.
(b)(i)	ZnO is a catalyst.	• Catalyst identified.		
(ii)		AND Line correctly drawn.		

(iii)	ZnO lowers the activation energy by providing an alternative pathway for the reaction to occur. Therefore, more reacting particles will collide with sufficient energy to overcome the activation energy. This results in a higher frequency of successful collisions, and therefore an increased rate of reaction.	• Recognises an alternative pathway is provided.	• Links lower activation energy to increased rate of successful collisions.	• Full answer.

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)(i)	$[H_3O^+] = 10^{-pH} = 10^{-2.4} = 0.00398$ mol L^{-1}	• Correct answer.		
(ii)	$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{1\times10^{-14}}{0.45} = 2.22\times10^{-14}$ mol L^{-1} $pH = -\log[H_3O^+] = 13.7$	• One step correct.	• Correct answer.	
(b)(i)	Solution A – sodium carbonate (Na_2CO_3) Solution B – sodium hydroxide ($NaOH$) Solution C – sodium chloride ($NaCl$)	• Solutions correctly identified.		
(ii)	The greater the concentration of hydroxide ions, the higher the pH / the more basic the solution. Sodium hydroxide is a strong base, which fully ionises in solution to produce a high concentration of hydroxide ions. $NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$ This high concentration of hydroxide ions gives NaOH the highest pH of the 3 solutions. Sodium carbonate is a salt. It dissociates into ions, as shown below. $Na_2CO_3(s) \rightarrow 2Na^+(aq) + CO_3^{2-}(aq)$ The carbonate ion is a weak base, which partially dissociates to produce a small amount of hydroxide ions. $CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$ This smaller amount of hydroxide ions gives sodium carbonate a lower pH than NaOH, although the solution is still basic. Sodium chloride is also a salt, which dissociates into ions in solution. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$ However, neither ion is acidic or basic so no further reaction occurs. This means the solution remains neutral and the pH is 7.	• Recognises that higher $[OH^-]$ / lower $[H_3O^+]$ leads to higher pH. • Correct equations for TWO substances.	• Explains difference in pH in terms of $[OH^-]$ / $[H_3O^+]$ and degree of dissociation for TWO substances.	• Fully justifies the identification of each substance with reference to degree of dissociation with correct equations.

(c)	When the temperature is increased, the reacting particles have more kinetic energy. This means there are more frequent collisions, and more of these collisions have sufficient energy to overcome the activation energy. This leads to an increased rate of successful collisions, and therefore an increased rate of reaction. This is shown on the graph, as the 50 °C line is initially steeper, indicating an increased rate of CO_2 production. Both lines end in the same point, as the same total volume of CO_2 is produced in both cases.	• Recognises increased kinetic energy of the particles. • States same volume of CO_2 produced in both reactions.	• Links increased frequency of successful collisions to either: The steepness of the line in graph. OR Increased kinetic energy of the particles. OR Increased collisions exceeding activation energy.	• Fully explains effect on temperature on the rate of reaction, with reference to graph.

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

Cut Scores

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