Assessment Schedule – 2023

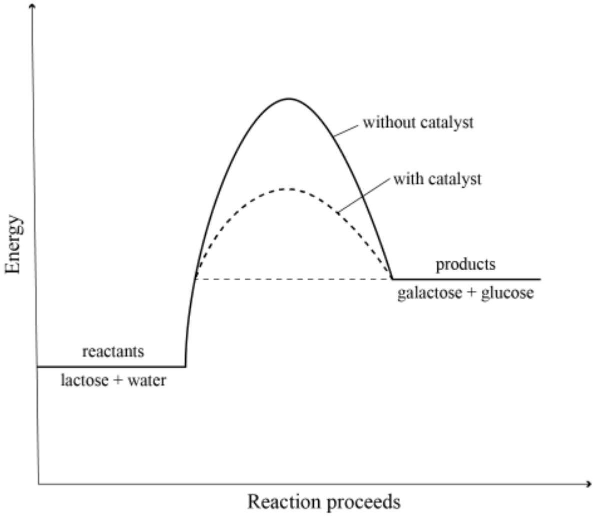
Chemistry: Demonstrate understanding of chemical reactivity (91166)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$[H_3O^+] = 10^{-pH} = 10^{-1.5} = 0.0316$ mol L^{-1}	• Correct concentration.		
(b)(i)	In section A the line is steep, indicating a fast rate of reaction. This is because initially, the concentration of the reactant particles is relatively high, resulting in a high rate of effective collisions. In section B, some reactant particles have been used up, so their concentration decreases. This results in a decreased rate of effective collisions so the rate slows and the line becomes less steep.	• Describes the rate of reaction for ONE stage of the reaction (fast, slow). OR Describes the relative concentration of reactant particles for ONE stage of the reaction (higher, lower).*)*	• Explains the rate of reaction for BOTH stages of the reaction and links this to the line on the graph.	
(ii)	At higher temperature, the kinetic energy of the particles is increased. This means the particles move with greater speed. This results in more frequent collisions, and a greater proportion of the collisions have sufficient energy to overcome the activation energy. This means a greater rate of successful collisions and an increased rate of reaction. This means the $NaHCO_3$ in the tablet would be consumed faster in the stomach, than in their experiment.	• Recognises increased kinetic energy of particles for body temp / higher temp. OR recognises more collisions exceeding Activation Energy.	• Links increased frequency of successful collisions to either: The increased kinetic energy of the particles for body temp / higher temp. OR Increased proportion / number of collisions exceeding activation energy for body temp / higher temp.	• Elaborates upon the effect of increased temperature and links this to faster consumption of $NaHCO_3$ in stomach.

(c)(i)	A strong acid fully dissociates / ionises in water. $HCl(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + Cl^-(aq)$ A weak acid, like propanoic acid, only partially dissociates / ionises in water. $CH_3CH_2COOH(aq) + H_2O(\ell) \rightleftharpoons CH_3CH_2COO^-(aq) + H_3O^+(aq)$	• Identifies difference between strong and weak acid in terms of degree of dissociation. OR Correct equations for both acids.		
(ii)	Conductivity depends upon the concentration of ions present in solution while pH is a measure of the concentration of hydronium, H_3O^+, ions. As hydrochloric acid is a strong acid, it completely dissociates and produces a high concentration of ions, and so it has good electrical conductivity. Propanoic acid is a weak acid, so only partially dissociates, producing a low concentration of ions, making it a poor electrical conductor. Hydrochloric acid also results in a higher concentration of hydronium ions than propanoic acid, meaning it has a lower pH value.	• Recognises conductivity depends upon total ion concentration. (not just H_3O^+) OR Recognises pH depends upon $[H_3O^+]$.	• Links degree of dissociation to conductivity OR pH for BOTH solutions. OR Links degree of dissociation to ion concentration and conductivity AND pH for ONE solution.	• Compares and contrasts difference in pH and electrical conductivity with correct equations (**can take evidence from question (c)(i))**.

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)	Lactase is a catalyst.	• Identifies lactase as a catalyst. AND Correct lines on graph.		
(ii)				
(iii)	The catalyst, lactase, provides an alternative pathway requiring lower activation energy for this reaction to proceed. As a result, more particles now have sufficient energy to overcome the activation energy requirement. Therefore, there are now more successful collisions per second, which results in a higher rate of reaction.	• Recognises catalyst provides an alternative pathway / lower activation energy.	• 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.

(b)(i)	$K_c = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$	• Correct K_c expression.		
(ii)	Removing the hydrogen gas as it forms will result in the system responding to minimise the effect of this change, favouring the forwards reaction and resulting in an increase in the amount of hydrogen produced.	• Identifies the correct direction of equilibrium shift for decrease in $[H_2]$.	• Links favouring of forwards reaction to replenish removed hydrogen to an overall increase in hydrogen production.	
(iii)	When the reaction mixture is heated, the system responds to minimise the effect of this change by removing heat energy from the system, favouring the endothermic reaction. As the K_c value is a measure of [products] / [reactant], an increase in K_c indicates a relative increase in the amount of products. This means the forwards reaction has been favoured and must therefore be endothermic.	• Recognises that the endothermic reaction is favoured. OR Recognises equilibrium has shifted to the right / makes more products. (accept more product or favours product)	• Links increased temperature to favouring of the endothermic reaction. OR Links direction of equilibrium shift to increase in K_c value.	• Endothermic nature of forwards reaction fully justified.

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
THREE (a)	Pair 1: HCO_3^- / CO_3^{2-} Pair 2: H_3O^+ / H_2O	• Both pairs correct.		
(b)(i)	$NaCH_3COO \rightarrow CH_3COO^- + Na^+$			
(ii)	$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$	• One correct equation. (ignore states).		
(iii)	$[H_3O^+] = \frac{K_w}{\left[OH^-\right]}$, $[H_3O^+] = \frac{1\times10^{-14}}{0.1}$ $[H_3O^+] = 1 \times 10^{-13}$ mol L^{-1} $pH = -\log(1 \times 10^{-13})$, $pH = 13$	• One step correct.	• Both steps correct.	
(iv)	pH is directly related to the hydronium ion concentration, the greater the $[H_3O^+]$ the lower the pH, and the greater the $[OH^-]$, the higher the pH. Potassium hydroxide is a strong base, and completely ionises in water into its respective ions resulting in the full available concentration of OH^- / higher $[OH^-]$. This means the reaction has a low concentration of $[H_3O^+]$ and a high pH value of 13. $KOH(s) \rightarrow K^+(aq) + OH^-(aq)$ By comparison, sodium ethanoate is a weakly basic salt. It fully dissolves in water, then behaves as a weak base, with only partial dissociation, producing a relatively small concentration of OH^- ions. This lower $[OH^-]$ compared with the KOH solution results in a higher $[H_3O^+]$ and therefore the lower pH value of 8.88.	• Recognises that higher pH is related to higher $[OH^-]$.	• Links degree of dissociation for ONE substance to concentration of $[OH^-]$ ions in solution. OR Links relative concentrations of $[OH^-]$ ions to pH for BOTH solutions.	• Relates pH to degree of dissociation both $[OH^-]$ and $[H_3O^+]$ with all relevant equations for both solutions (can take evidence from (b)(i) and (ii)).

(c)(i)	$CF_4(g) + CO_2(g) \rightleftharpoons 2COF_2(g)$	• Correct equation. *(including arrow, ignore states)*		
(ii)	$\frac{[0.105]^2}{[x][x]} = 2.00$ $\frac{[0.105]^2}{[x^2]} = 2.00$ $x^2 = \frac{[0.105]^2}{2} = 0.0055125$ $x = \sqrt{0.0055125} = 0.0742 \text{ mol L}^{-1}$	• Correct substitution of numbers OR One step correct with incorrect substitution.	• Correct answer with ~~minor~~ error (eg forgetting to square root answer, computational error).	• Correct answer with unit.
(iii)	When the pressure is increased, the system is unable to respond to decrease the pressure. This is because both sides of the equation contain two gaseous molecules. As a result, the position of the equilibrium is unaffected.	• Identifies equal number of gas moles. OR Recognises no effect on equilibrium position.	• Links equal number (2) of **gas** moles / particles / molecules to no effect on equilibrium position when pressure is increased.	

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

Cut Scores

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