Assessment Schedule – 2017

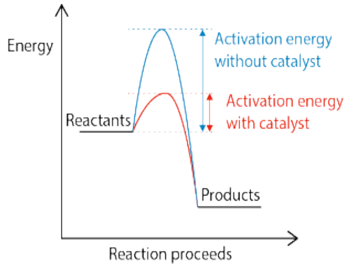
Chemistry: Demonstrate understanding of chemical reactivity (91166)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i)	$C_2H_5COO^-(aq)$, $H_3O^+(aq)$	• Products correct with charges.		
(ii)	Propanoic acid transfers a proton / H^+ to the water so it is the acid and it forms a conjugate base, $C_2H_5COO^-$. The water, H_2O, accepts the proton and therefore acts as a base, forming H_3O^+, hydronium ion, which is the conjugate acid.	• Identifies TWO of acid, base, conjugate acid, conjugate base.	• Explains proton transfer and gives BOTH correct conjugate acid-base pairs.	
(b)	EQUATION ONE: $CH_3COONa(s) \rightarrow Na^+(aq) + CH_3COO^-(aq)$ The salt dissociates / dissolves into ions in water. The ethanoate ions then react with water to form $CH_3COOH(aq)$ and $OH^-(aq)$. EQUATION TWO: $CH_3COO^-(aq) + H_2O(\ell) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$ The OH^- ions produced make this a basic solution.	• Identifies CH_3COONa as basic with a correct dissociation equation (ONE or TWO) OR Identifies CH_3COONa as a basic solution since OH^- produced / accepts a proton / cannot donate a proton.	• Links basic nature of CH_3COONa / CH_3COO^- to its ability to produce OH^- ions in solution / accept a proton, including equation TWO.	
(c)(i) (ii)	$[H_3O^+] = 10^{-pH}$ $= 10^{-11.6}$ $= 2.51 \times 10^{-12}$ mol L^{-1} $[OH^-] = \dfrac{K_w}{[H_3O]^+}$ $= 3.98 \times 10^{-3}$ mol L^{-1} pOH = $-\log(2.96 \times 10^{-4}) = 3.53$, so pH = 14.0 – 3.53, pH = 10.5. OR $[H_3O]^+ = \dfrac{K_w}{[OH]^-} = \dfrac{1 \times 10^{-14}}{2.96 \times 10^{-4}} = 3.38 \times 10^{-11}$ So, pH = $-\log(3.38 \times 10^{-11}) = 10.5$.	• Calculates $[H_3O^+]$ for either (i) OR (ii). • $[OH^-]$ calculation process correct for (i), with incorrect $[H_3O^+]$.	• Correct $[OH^-]$ answer (units not required). OR pH correctly calculated.	• ALL three calculations correct with units (accept 2-4 significant figures).

(d)	Charged particles are needed in a solution to conduct electricity. (The particles could be positively or negatively charged). Sodium carbonate is a good conductor of electricity because it is a salt, so will **dissociate / dissolve fully in water** to produce a **high [ions]**. Unlike sodium carbonate, ammonia is not a salt / ionic; it is a **weak base** and forms an equilibrium with water / **only partially dissociates in water** to produce **fewer ions / lower [ions]** in solution. $NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ Therefore, $NH_3(aq)$ is a poor conductor of electricity, whereas $Na_2CO_3(aq)$ is a good conductor of electricity. Compare: Both dissociate in solution to produce ions, so both can conduct electricity. Contrast: Sodium carbonate dissociates completely to produce high [ions], whereas ammonia only partially dissociates to produce low**er** [ions].	- Recognises that charged particles (*not electrons*) are required for electrical conductivity. OR Na_2CO_3 is a good conductor and NH_3 is a poor conductor.	- Links degree of dissociation in water to the **amount / concentration of ions** (*not electrons*) present for ONE solution.	- Compares and contrasts the degree of dissociation and [ions] (*not just* OH^-) available in each solution, and links to electrical conductivity. *Equations not required.* *Must compare and contrast to gain E8* *Example of minor error:* Na_2CO_3 *is a strong base.*

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)	The iron is added to act as a catalyst. This speeds up the rate of reaction because a catalyst provides an alternative pathway for the reaction with a lower activation energy level. Therefore, **more particles / collisions have sufficient energy to overcome the activation energy**, and so there are more effective collisions / faster rate of reaction.  	• Identifies iron as a catalyst OR Catalysts provide an alternative pathway for this reaction. • The catalyst is not used up OR Lower activation energy is needed.	• Alternative pathway with lower activation energy. OR More collisions have sufficient energy to overcome the activation energy, and so there are more effective collisions / faster rate of reaction.	• Explains the role of the catalyst linked to the activation energy and collision theory. Must have explanation in 'bold'.
(b)(i)	$K_c = \frac{[NH_3(aq)]^2}{[N_2(aq)][H_2(aq)]^3}$	• K_c expression correct.		
(ii)	$K_c = \frac{0.105^2}{0.0821 \times 0.0583^3}$ $= 677$ No, the reaction is not at equilibrium because 677 > 640 (values must be equal for a reaction to be at equilibrium). *Accept answers between 676 – 678.*	• One correct step of the calculation (correct substitution) OR Correctly compares incorrect K_c to 640.	• Correct calculation and explanation.	
(c)	When 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 decreased. Since there will be fewer products and more reactants, the equilibrium is favouring the reactants, so adding heat favours the reverse reaction / the position of equilibrium shifts left. Hence, the formation of ammonia gas / forward reaction, is exothermic. (Temperature is the only factor that can change the K value in an equilibrium).	• Identifies that a temperature increase shifts equilibrium in endothermic direction.	• Links change in K_c value to changes in the relative concentrations of reactants or products.	• Justifies forward direction as exothermic by linking the effect of increasing temperature to the change in K 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 (minor error or omission)	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	The **increased temperature** means an increase in the rate of the reaction because the **kinetic energy of the particles has increased**. This means the **particles move faster**, **increasing the frequency of collisions / more collisions per second**, resulting in the CO_2 gas being lost in a shorter period of time at 40°C than 20°C. In addition, the collisions are more likely to be **successful / effective** because the **average kinetic energy of the particles has increased**, so a **greater proportion of particles have enough / sufficient energy to overcome the activation energy**. This causes the rate of reaction to increase. Overall, the same mass is lost in both reactions.	• Increased (kinetic) energy of the particles OR Increased number of collisions OR Particles move faster.	• Links **temperature and kinetic energy** to the frequency / effectiveness of the collisions.	• Links temperature and **kinetic** energy to frequency of collisions and **activation energy**, and the increased rate of reaction. (*For E8, indication of the same mass of CO_2 released OR same mass of reaction mixture at the end*).
(b)(i)	Adding water to this equilibrium means there has been an **increase in (**concentration of) **a product**. The system will react to reduce this change, so the backward reaction will be favoured to **use up** *(idea required for Excellence)* some of the extra product. This results in an increased concentration of the pink $[Co(H_2O)_6]^{2+}$ ion, so the solution will turn pink or the pink colour will intensify.	• Identifies shift in equilibrium with a reason for (i) or (ii). e.g. shifts to left to minimise the change.	• Links increase in concentration / amount of product to the correct direction and colour change, **using equilibria principles** OR Links exothermic direction to the colour change, **using equilibria principles**.	• Demonstrates comprehensive understanding of equilibria principles with respect to colour changes resulting from changes as evidenced by TWO out of THREE from (b)(i), (b)(ii), and (c).
(ii)	The ice-cold water will cause the reaction to move in the exothermic direction to compensate for the loss of heat energy / **release heat energy** *(for Excellence)* into surroundings. Because this reaction is endothermic (positive ΔH value), the exothermic direction will be backwards, so the colour of the solution will become pink or the pink colour will intensify.	• Identifies reaction turns pink for BOTH reactions.		
(c)	The increase in pressure favours the side with the fewest moles of **gas** on it, so the reaction will move in the forward direction because there is only one mole of N_2O_4 gas compared to 2 moles of NO_2 gas. This will cause the colour to fade from a darker to a lighter brown. (It won't go colourless because both gases are still present in the mixture.)	• Identifies that the brown colour will fade OR Recognises change in pressure / volume favours products or fewer number of gas moles.	• Links the effect of pressure to moles of **gaseous** particles and to the change in colour. (*Not colourless*)	

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No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e (minor error or omission)	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 14	15 – 18	19 – 24