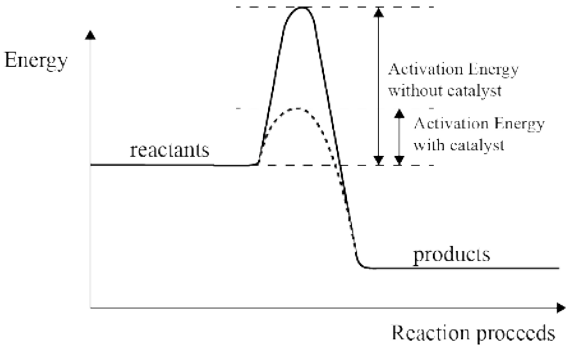
Assessment Schedule – 2018

Chemistry: Demonstrate understanding of chemical reactivity (91166)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Increased temperature **increases the kinetic energy** of the particles, causing them to **move faster** and **collide more frequently**. The collisions that occur are more likely to have **sufficient energy to overcome the activation energy barrier** / more particles have sufficient energy to overcome the activation energy barrier. So the rate of reaction is increased as there will be **greater frequency / more successful collisions per second / unit time**. DO NOT ACCEPT COLLIDE WITH GREATER **FORCE.**	• increased (kinetic) energy of the particles. OR Faster moving particles. OR More frequent collisions.	• Links temperature AND (kinetic) energy / speed to the **frequency** (per second) of effective collisions.	• Explains the relationship of temperature and **kinetic** energy of particles linking to activation energy for a reaction and frequency of effective collisions. Must refer to 'kinetic energy' rather than just 'energy'. Must refer to activation energy.

(b)(i)	The ammonium molybdate is a **catalyst**, which speeds up the rate of reaction by **providing an alternative pathway** for the reaction to occur with a **lower activation energy** barrier to be overcome. Now **more reactants will have sufficient energy to overcome the activation energy**, resulting in an increase in the rate of reaction. DO NOT ACCEPT COLLIDE WITH GREATER **FORCE.**  	- Identifies role of catalyst. Diagram can provide evidence. - Catalyst provides an alternative pathway for this reaction. OR Catalyst lowers activation energy. Diagram can provide evidence.	- Links ammonium molybdate to the alternative pathway with lowered **activation** energy to a faster reaction rate. Diagram can provide evidence. OR Links ammonium molybdate to more reactants will have sufficient energy to overcome the **activation energy.**	- Explains the role of catalyst and links to its effect on reaction rate. Must refer to '**more reactants will have sufficient energy to overcome the activation energy' concept.** Diagram must be labelled both with and without catalyst. Must have diagram for E.
(ii)	$\left[\mathrm{H_3O^+}\right] = 10^{-\mathrm{pH}} = 1.58 \times 10^{-11}\ \mathrm{mol\ L^{-1}}$ $\left[\mathrm{OH^-}\right] = \dfrac{K_\mathrm{w}}{\left[\mathrm{H_3O^+}\right]} = 6.31 \times 10^{-4}\ \mathrm{mol\ L^{-1}}$	- ONE correct calculation from (ii) and (iii).	- TWO correct calculations from (ii) and (iii).	- All THREE calculations correct for (ii) and (iii) with correct units and significant figures (accept 2 – 4).
(iii)	$\left[\mathrm{H_3O^+}\right] = \dfrac{K_\mathrm{w}}{\left[\mathrm{OH^-}\right]} = \dfrac{1 \times 10^{-14}}{0.0125}$ $= 8.00 \times 10^{-13}\ \mathrm{mol\ L^{-1}}$ $\mathrm{pH} = -\log_{10}\left[\mathrm{H_3O^+}\right] = 12.1$ OR $\mathrm{pOH} = -\log_{10} 0.0125 = 1.90$ $\mathrm{pH} = 14 - 1.9 = 12.1$			
(iv)	When sodium ethanoate dissolves in water, the ions separate. EQUATION ONE: $\mathrm{CH_3COONa}(s) \rightarrow \mathrm{CH_3COO^-}(aq) + \mathrm{Na^+}(aq)$ The ethanoate ions then react with water. EQUATION TWO: $\mathrm{CH_3COO^-}(aq) + \mathrm{H_2O}(\ell) \rightleftharpoons \mathrm{CH_3COOH}(aq) + \mathrm{OH^-}(aq)$ The $\mathrm{OH^-}$ ions produced make this a basic solution.	- Writes a correct equation (ONE or TWO). OR Identifies $\mathrm{CH_3COONa}$ as a basic solution since $\mathrm{OH^-}$ produced / accepts a proton / cannot donate a proton.	- Links the basic nature of $\mathrm{CH_3COO^-}$ to its ability to produce $\mathrm{OH^-}$ ions in solution / accept a proton, and EQUATION TWO correct (states not needed).	

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
TWO (a)	$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$	• Correct equilibrium expression. **Do not accept round brackets.**		
(b)(i) (ii)	$K_c = \frac{0.093^2}{0.1^2 \times 0.2} = 4.32$ The K_c value is larger than 1 so there are more products than reactants at equilibrium.	• One step of calculation correct (correct substitution). Allow error carried forward from (a). • Identifies products are favoured. Allow error carried forward.	• Correct calculation. No penalty for significant figures. Allow error carried forward from (a). • Links the K_c value being larger than 1 to more products than reactants. Allow error carried forward. **Do not accept generic statements.**	
(c)	If the sulfur trioxide is removed as it is produced, **[SO_3] will decrease**, so the equilibrium will move to minimise the change (stress placed on the system). This means the reaction will move forward to **replace the lost sulfur trioxide**. This will **increase the yield of the desired product.**	• Identifies the forward direction with a generic reason, e.g. to minimise the change.	• Links EITHER change in concentration OR pressure to the direction the reaction will move, using equilibria principles. Must refer to gaseous particles for pressure.	• Analyses both situations (change in concentration and change in volume / pressure) to link correctly to equilibrium principles and to **yield of sulfur trioxide**. Must refer to idea of '**replace the lost sulfur trioxide' for (c).** Must refer to number of 'gaseous' particles for (d).
(d)	Increasing the size of the reaction vessel **decreases the pressure** of the system. In order to minimise this change / stress, the reaction moves to **increase the number of gaseous particles**. For this reaction, the greatest number of gaseous particles is the reactants side so the reaction will **move backwards towards the reactants.** This has the effect of **decreasing the amount of sulfur trioxide.**	• Identifies EITHER the backwards reaction with a generic reason OR side with more (gaseous) particles.		

(e)	When the **temperature decreases** to 450°C, the reaction moves in the **exothermic direction to produce more heat**. Since the **K_c value increased**, **more products** and less reactants are present. This means the reaction produces more products when the temperature drops. This means the oxidation of sulfur dioxide to sulfur trioxide is an exothermic reaction.	- States that a decrease in temperature favours the exothermic reaction.	- Links increase in K_c value at lower temp to changes in the relative concentrations of reactants or products, e.g. favours products / forward reaction.	- Justifies the forward reaction as exothermic by explaining how the decrease in temperature favours the exothermic reaction, and the increasing K_c value results in a change in relative concentrations of reactants or products. **Must refer to heat energy released for E8.**

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	3m	4m	2e with minor error or omission e.g. omits ‘to produce more heat’ for (e) OR does not link to yield of product for (c)/(d).	2e

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons SO_4^{2-}(aq) + H_3O^+(aq)$ $HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons H_2SO_4(aq) + OH^-(aq)$	• Products in one reaction correct.		
(b)	KOH is a **strong base**, so it will ionize / **dissociate completely**, producing **many OH^- ions**. $KOH(s) \rightarrow K^+(aq) + OH^-(aq)$ NH_3 is a **weak base**, so it only **partially ionizes / dissociates** in water producing **fewer OH^- ions**. $NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ pH depends on the $[H_3O^+]$ ions. **As $[OH^-]$ increases, $[H_3O^+]$ decreases and pH is higher.** Since NH_3 produces fewer $[OH^-]$ ions, its pH is smaller than KOH. Conductivity of a solution depends on presence of ions. KOH solution has **more ions (not just** OH^- **ions) than** NH_3 solution, so is a better conductor.	• Distinguishes the strong base from the weak base (equations can provide evidence). • Recognises that conductivity of a solution depends upon presence of **ions (accept charged particles, but not electrons)**. • Recognises that pH is linked to concentration of H_3O^+ ions (OH^- ions).	• Links conductivity of each solution to the **degree of dissociation** and relative amount / concentration o**f ions** (correct ions in equations may provide evidence for ions)**.** • Links pH of each solution to the **degree of dissociation** and relative amount / concentration of H_3O^+ ions (OH^- ions).	• Links conductivity and pH correctly to amount and relative concentration of ions including **ratio of OH^- to H_3O^+** using **relevant equation for ONE solution**. **Must not refer to only OH^- ions for conductivity.** Ratio idea: **As $[OH^-]$ increases, $[H_3O^+]$ decreases and pH is higher. Required for E8.**
(c)(i)	$[H_3O^+]$ of $HNO_3 = 10^{-0.7} = 0.200$ mol L^{-1} This is the same as the concentration of acid, so it is a strong acid that fully dissociates, producing lots of H_3O^+. $[H_3O^+]$ of $CH_3COOH = 10^{-2.73} = 0.00186$ mol L^{-1} This is less than the concentration of acid, so it is a weak acid that only partially ionises in water, producing fewer H_3O^+ ions than HNO_3.	• Identifies one of the acids as weak or strong. OR One $[H_3O^+]$ calculation. Note: Evidence can come from (ii).	• **Links** calculated amount of H_3O^+ ions to strength for ONE acid. e.g. Nitric acid is a stronger acid since it has a higher $[H_3O^+]$.	• Explains the relative H_3O^+ concentrations and the rate of reaction in terms of the strength (degree of dissociation) for BOTH acids. **Must refer to collisions per second/frequency of collisions for E8.**
(ii)	Both acids will react with the cleaned Mg ribbon, but since HNO_3 completely dissociates, it has a **higher concentration of H_3O^+**, so HNO_3 will have a **faster rate** of reaction with Mg than CH_3COOH. There are **more H_3O^+ ions** available to react in a given volume so there will **be more effective collisions per second.**	• Identifies correct acid as faster or slower reaction.	• **Links** calculated amount of H_3O^+ ions to reaction rate for ONE acid. e.g. Nitric acid has a faster rate of reaction since it has a higher $[H_3O^+]$.	

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	1a	2a	3a	4a	2m	3m	2e with minor error or omission, e.g. does not refer to [H3O$^+$] when explaining pH for (b).	2e

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 14	15 – 18	19 – 24