Assessment Schedule – 2019

Chemistry: Demonstrate understanding of chemical reactivity (91166)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i) (ii)	Identifies Cu as a catalyst. Cu provides an **alternative pathway** with **lower activation energy** for the reaction. Therefore, **more reacting particles will collide with sufficient (kinetic) energy above activation energy**, (resulting in a higher frequency of successful collision) resulting in an increase in the rate of reaction.	• States a catalyst. AND Catalyst speeds up reaction rate. OR Catalyst lowers activation energy. OR Catalyst provides alternative pathway..	• States a catalyst. AND Links alternative pathway with lower activation energy. OR Links catalyst with more reacting particles colliding with sufficient (kinetic) energy above activation energy.	• Links role of catalyst with reaction rate AND collision theory.
(b)(i) (ii)	Line B. The lines finish in the same position as there are **(1)** the same amounts of reactants, thereby producing **(2)** the same amount of products. **(3)** The only difference is the rate at which the products are produced, i.e. reaction at higher temperature produces products at a faster rate. An increased temperature means an increase in the rate of the reaction because the **kinetic energy (E_K) of the particles has increased**. This means the particles **move faster**, **increasing the frequency of (successful / effective) collisions / more collisions per second**. In addition, a **greater percentage / proportion of collisions are likely to be successful because more particles have enough kinetic energy to overcome the activation energy**. This causes the rate of reaction to increase / more gas to be produced.	• Line identified. AND One correct statement (1 – 3). • Recognises there is increased (kinetic) energy of the particles. • Recognises that faster moving particles collide more often / with more energy.	• Line identified. AND Links amount / moles of substance to the finish point (two out of three statements). • Links temperature and **kinetic** energy to the frequency of collisions/collisions per second. OR Explains that an increase in temperature means more particles have sufficient **kinetic** energy to overcome the activation energy.	• Explains the relationship of temperature and **kinetic** energy of particles, linking to activation energy for a reaction and frequency of (effective) collisions.

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.	2e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)(i)	$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$	• K_c expression correct.		
(ii)	There are four moles of **gas** particles on the reactant side of the equation, and two moles of **gas** particles on the product side of the equation. Therefore, when there is an increase in pressure, the system would shift towards the products (to minimise the stress on the equilibrium) since there are fewer gas molecules on the product side. This would increase the yield of ammonia, so would be an advantage for the manufacturer.	• Increase in pressure favours the side with fewer (gas) particles.	• Links increase in amount of ammonia produced in (ii) to equilibrium shifting towards side with least number of **gas** molecules OR • Links increase in amount of ammonia produced in (iii) to equilibrium shifting towards products to replace ammonia removed to therefore re-establish the equilibrium.	• Justifies increased production of ammonia for BOTH changes in conditions with reference to their advantage to manufacturers.
(iii)	As ammonia gas is removed, the concentration of the products decreases. The system will oppose the change by shifting in the forward direction to form more ammonia/replace ammonia. In industry, this is an advantage as it maximises the amount of ammonia produced.	• Decrease in (amount / concentration) of products will cause equilibrium to shift towards products to minimise change, e.g. the removal of ammonia causes equilibrium to shift towards products to minimise the change.		
(b)	As the temperature increases, the system will act to reduce the temperature by favouring the endothermic direction to absorb some of the extra heat energy. Since the reaction has a negative $\Delta_r H$, this means that the forward reaction is exothermic and produces heat energy. So, an increase in temperature will cause the equilibrium to shift towards the reactants and therefore the concentration of reactants will increase. A higher concentration of reactants (compared to products) will cause the K_c value to decrease.	• Recognises that an increase in temperature moves the equilibrium in the endothermic direction.	• Links temperature increase to the equilibrium shifting towards reactants, and therefore an increase in **concentration** of reactants. OR • Links increase in amount / concentration of reactants to decrease in K_c.	• Justifies the decrease in K_c by linking to equilibrium principles and relative amount / concentration of reactants (and products).

(c)(i)	$[NO_2] = \sqrt{K_c[N_2][O_2]^2}$ $= \sqrt{(8.3\times10^{-10})\times0.110\times0.230^2}$ $= \sqrt{4.830\times10^{-12}}$ $= 2.20\times10^{-6}$ mol L^{-1} 3sf	• One step of calculation is correct, e.g. correct substitution.	• Calculation correct.	• Calculation correct with unit and 2–4 significant figures. AND
(ii)	When $N_2(g)$ is added, the system will oppose the change (increase in concentration of $N_2(g)$) and therefore the position of the equilibrium will shift in the forward direction to use up some of the added $N_2(g)$. This means more $NO_2(g)$ will be produced. However, the ratio of the concentrations of the reactants and products will remain the same, consequently the value of K_c remains unchanged. Only a change in temperature will affect the value of K_c.	• K_c is unchanged.	• K_c is unchanged with reason, e.g. K_c is a constant at a given temperature OR Change in concentration does not affect Kc OR the ratio of the concentrations of the reactants and products will remain the same.	• Effect on K_c when more $N_2(g)$ is added is explained, e.g. The value of K_c is unchanged by a change in concentration since K_c is a constant at a given temperature.

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)	$HNO_3(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + NO_3^-(aq)$ $CH_3COOH(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$	• Writes equation for ONE substance in water (arrows must be correct).	• Links ONE equation to explanation of substance being acidic.	
(ii)	When these substances dissociate / ionise in water, they produce hydronium ions / donate protons. OR When hydronium ions are in greater concentration than hydroxide ions (OH^-), the pH will be below 7 and therefore acidic.			
(b)(i)	$\text{pH} = -\log[H_3O^+] = 1.79$ $[OH^-] = \frac{K_w}{[H_3O^+]} = \frac{1\times10^{-14}}{0.0164} = 6.10\times10^{-13}\text{ mol L}^{-1}$	• ONE correct calculation.	• EITHER (i) OR (ii) correct.	• BOTH (i) and (ii) correct with units where applicable and 2–4 significant figures.
(ii)	$[H_3O^+] = 10^{-\text{pH}} = 10^{-9.4} = 3.98\times10^{-10}\text{ mol L} - 1$ $[OH^-] = \frac{K_w}{[H_3O^+]} = 2.51\times10^{-5}\text{ mol L}^{-1}$			

(c)(i)	**A**: NH_4Cl **B**: HCl **C**: NaCl **D**: NaOH	• Identifies TWO solutions correctly.		
(ii)	pH reflects the concentration of H_3O^+ ions. The higher the pH, the lower the $[H_3O^+]$. Ammonium chloride fully dissociates into ions. $NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq)$ The NH_4^+ partially dissociates/ionises in water, producing fewer H_3O^+ ions, so is a weak acid where pH does not equal the –log$[H_3O^+]$, so **A** is NH_4Cl. **(1)** $NH_4^+ + H_20(\ell) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$ As a strong acid, HCl completely dissociates in water, resulting in a high $[H_3O^+]$ ions and a low pH. For a strong acid, pH = –log $[H_3O^+]$. Hence **B** is HCl. **(2)** $HCl(aq) + H_20(\ell) \rightarrow H_3O^+(aq) + Cl^-(aq)$ **C** is NaCl as it is a neutral salt that completely dissociates in water. Neither Na or Cl ions react further when dissolved in water. Hence the $[H_3O^+]$ remains the same as $[OH^-]$, and so the pH is 7. **(3)** $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$ **D** is NaOH. NaOH is a strong base and so completely dissociates in water resulting in a high $[OH^-]$, low $[H_3O^+]$ and a high pH. **(4)** $NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$	• Recognises relative **amount of H_3O^+** for at least ONE solution. • Recognises degree of dissociation for two solutions, e.g. could identify solutions as strong or weak acids / bases.	• Explains differences in pH in terms of **$[H_3O^+]$ / amount of H_3O^+** ions **and degree of dissociation** for TWO solutions. e.g. HCl is a strong acid that completely dissociates to produce lots of H_3O^+ ions. NaOH is a strong base that completely dissociates to produce lots of OH^- ions.	• Relates the pH for THREE solutions to the **degree of dissociation** in water and **$[H_3O^+]$ / amount of H_3O^+, including three equations (from 1 – 4).**
(iii)	Charged particles that are free to move are needed to conduct electricity. NH_4Cl, HCl, NaOH, and NaCl are all good conductors of electricity because they completely dissociate in water, releasing ions into solution giving a relatively high concentration of ions to carry charge.	• Recognises that conductivity of a solution depends upon presence of ions (accept charged particles, but not electrons).	• Explains conductivity by linking degree of dissociation in water to relative amounts of **ions** present for TWO solutions.	• Relates conductivity for ALL solutions to the degree of dissociation in water and the relative amounts of ALL ions (not just 'charged particles' or H_3O^+) in solution.

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

Cut Scores

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