AQA Qualifications

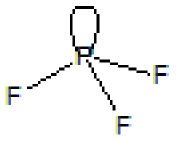
A-level

Chemistry

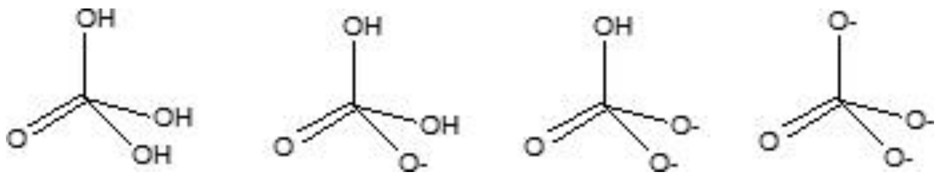
Paper 1 (7405/1): Inorganic and Physical Chemistry
Mark scheme

7405
Specimen paper

Version 0.1

Question	Marking guidance	Mark	Comments
01.1	$1s^2 2s^2 2p^6 3s^2 3p^3$	1	Allow correct numbers that are not superscripted
01.2	 Pyramidal PF_3 with or without lone pair on P Bond angle 107°	1 1	 Allow 106°–108°
01.3	(8 electrons in outside shell so) 4 electron pairs Repel as far as possible Lone pair repels more than bonding pairs So tetrahedral angle or angle of 109(.5)° decreases (to 107°)	1 1 1 1	4 electron pairs in outside shell of P must be implied
01.4	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$	1	Allow correct numbers that are not superscripted
01.5	Tetrahedral (shape) 109.5°	1 1	 Allow 109°
01.6	Too many electrons in d sub-shell / orbitals	1	

Question	Marking guidance	Mark	Comments
02.1	Number of protons increases (across the period) / nuclear charge increases Attraction between the nucleus and electrons increases	1 1	
02.2	Sulfur molecules are bigger than phosphorus molecules because sulfur molecules are S_8, phosphorus molecules are P_4 Therefore, van der Waals / dispersion / London forces between molecules are stronger in sulfur	1 1 1	Allow sulfur molecules have bigger surface area and sulfur molecules have bigger M_r
02.3	Contains O^{2-} ions O^{2-} ions accept a proton from water forming OH^- ions	1 1	$O^{2-} + H_2O \longrightarrow 2OH^-$ scores both marks
02.4	$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$ (or ionised phosphates)	1	
02.5	0 to 1	1	

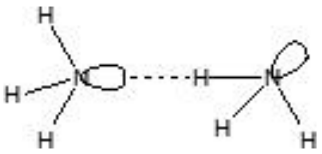
02.6	Any **one** of: 	1	

Question	Marking Guidance	Mark	Comments
03.1	F^-	1	
03.2	$E^\ominus$ $SO_4^{2-}/SO_2 < E^\ominus$ Br_2/Br^-	1	Allow correct answer expressed in words, eg electrode potential for sulfate ions / sulfur dioxide is less than that for bromine / bromide
03.3	$Pt\|H_2\|H^+\|\|Br_2\|Br^-\|Pt$	1	Ignore state symbols
03.4	1.23 (V)	1	
03.5	Oxygen in O_2 gas has oxidation state zero which changes to –2 Because electrons are added to O_2 (oxygen)	1 1	Oxidation state of oxygen decreases by 2
03.6	A fuel cell converts more of the available energy from combustion of hydrogen into kinetic energy of the car / an internal combustion engine wastes more (heat) energy	1	

Question	Marking guidance	Mark	Comments
04.1	ΔH = Σ(bonds broken) – Σ(bonds formed) = $\frac{1}{2}$(N≡N) + $\frac{3}{2}$(H–H) – 3(N–H) **OR** = $\frac{1}{2} \times 944 + \frac{3}{2} \times 436 - 3 \times 388$ = –38 (kJ mol^{-1})	1 1 1	Allow 1 mark for +38 (kJ mol^{-1})
04.2	Mean bond enthalpy is not the same as the actual N–H bond enthalpy in NH_3	1	
04.3	When a change is applied to a system at equilibrium, the position of equilibrium moves to oppose the change	1	

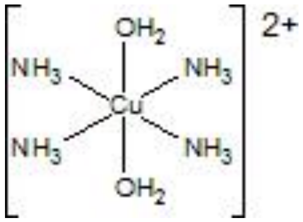
04.4	2 mol of gas form 1 mol At high pressure the position of equilibrium moves to the right to lower the pressure / oppose the high pressure This increases the yield of ammonia	1 1 1	
04.5	Impurities or sulfur compounds block the active sites	1	
04.6	$K_c = \dfrac{[NH_3]}{[N_2]^{0.5} \times [H_2]^{1.5}}$	1	
04.7	Moles of nitrogen = 1 – 0.36/2 = 0.82 Moles of hydrogen = 3 – (0.36 × $\frac{3}{2}$) = 2.46 $K_c = \dfrac{(0.36/0.2)}{[(0.82/0.2)^{0.5}(2.46/0.2)^{1.5}]}$ $= \dfrac{1.8}{2.025 \times 43.14}$ = 0.021	1 1 1 1	M1 and M2 can be scored if answer to 4.6 is incorrect If correct K_c for 2 mol of ammonia, allow 4 marks for answer of 4.0–4.4 × 10^{-4} Allow 0.020–0.022

Question	Marking guidance	Mark	Comments
05.1	$\Delta S = \Sigma S$(products) – ΣS(reactants) $= 193 - 192/2 - 131 \times \frac{3}{2}$ $= -99.5$ J K^{-1} mol^{-1}	 1 1	 Units essential
05.2	$\Delta G = \Delta H - T\Delta S$ $= -46.2 - \frac{773 \times (-99.5)}{1000}$ $= +30.7$ kJ mol^{-1}	 1 1	 Mark consequentially to ΔS in 5.1 Units essential
05.3	When $\Delta G = 0$, $\Delta H = T\Delta S$ $T = \Delta H/\Delta S = -46.2 \times (1000/-99.5)$ $T = 464$ (K)	 1 1	 Mark consequentially to ΔS in 5.1

05.4	Diagram marks:  Diagram of a molecule showing 3 N–H bonds and one lone pair Diagram showing δ+ and δ– charges Diagram showing δ+ hydrogen on one molecule attracted to lone pair on a second molecule Explanation mark: Hydrogen bonding is a strong enough force to allow a liquid to form easily	1 1 1 1	

Question	Marking guidance	Mark	Comments
06.1	Burette Can deliver variable volumes	1 1	
06.2	The change in pH is gradual / not rapid at the end point An indicator would change colour over a range of volumes of sodium hydroxide	1 1	 Allow indicator would not change colour rapidly / with a few drops of NaOH
06.3	$[H^+] = 10^{-pH} = 1.58 \times 10^{-12}$ $[OH^-] = 1 \times 10^{-14}/1.58 \times 10^{-12} = 6.33 \times 10^{-3}$ (mol dm^{-3})	1 1	 Allow 6.31–6.33 × 10^{-3} (mol dm^{-3})
06.4	$K_a = \dfrac{[NH_3][H^+]}{[NH_4^+]}$	1	
06.5	At this point, $[NH_3] = [H^+]$ Therefore $K_a = \dfrac{[H^+]^2}{[NH_4^+]}$ $[H^+] = 10^{-4.6} = 2.51 \times 10^{-5}$ $K_a = (2.51 \times 10^{-5})^2/1 = 6.31 \times 10^{-10}$ (mol dm^{-3})	 1 1 1	

Question	Marking guidance	Mark	Comments
07.1	**Y**	1	
07.2	**X**	1	
07.3	Jump in trend of ionisation energies after removal of fifth electron Fits with an element with 5 outer electrons ($4s^2 3d^3$) like V	1	
07.4	Calcium has no electron energy levels with a difference in energy corresponding to the energy of visible light Vanadium has d electrons that can be excited to a higher level Some frequencies of visible light are absorbed The other frequencies of white light are transmitted (or reflected) causing the appearance of colour	1 1 1 1	Allow calcium has no electrons in its d orbital Allow colour or wavelength instead of frequencies in M3 and M4
07.5	Reducing agent Two different colours of solution Each colour due to vanadium in a different oxidation state	1 1 1	

Question	Marking guidance	Mark	Comments
08.1	Blue precipitate	1	
	Dissolves to give a dark blue solution	1	
08.2	diagram of copper complex (ignore charges) 	1	
08.3	Octahedral	1	
08.4	90°	1	
08.5	$[Cu(NH_3)_4(H_2O)_2]^{2+} + 2NH_2CH_2CH_2NH_2 \longrightarrow [Cu(NH_2CH_2CH_2NH_2)_2(H_2O)_2]^{2+} + 4NH_3$	1	
08.6	Cu–N bonds formed have similar enthalpy / energy to Cu–N bonds broken	1	
	Same number of bonds broken and made	1	

08.7	3 particles form 5 particles / disorder increases because more particles are formed / entropy change is positive Free-energy change is negative	1 1	

Question	Marking guidance	Mark	Comments
09.1	Start a clock when KCl is added to water	1	
	Record the temperature every subsequent minute for about 5 minutes	1	Allow record the temperature at regular time intervals until some time after all the solid has dissolved
	Plot a graph of temperature vs time	1	
	Extrapolate back to time of mixing = 0 and determine the temperature	1	
09.2	Heat taken in = $m \times q \times \Delta T = 50 \times 4.18 \times 5.4 = 1128.6$ J	1	Max 2 if 14.6 °C used as ΔT
	Moles of KCl = 5.00/74.6 = 0.0670	1	
	Enthalpy change per mole = +1128.6/0.0670 = 16 800 J mol^{-1}	1	
	= +16.8 (kJ mol^{-1})	1	
09.3	$\Delta H_{solution} = \Delta H_{lattice} + \Sigma(\Delta H_{hydration\ of\ ions})$	1	Allow correct cycle
	$\Delta H_{lattice} = –82.9 – (–1650 + 2 \times –364)$	1	
	$\Delta H_{lattice} = +2295$ (kJ mol^{-1})	1	
09.4	Magnesium ion is smaller than the calcium ion	1	
	It attracts the chloride ion more strongly / stronger ionic bonding	1	

Question	Marking guidance	Mark	Comments
10.1	**Q** is calcium or magnesium	1	
	bromide	1	
	R is aluminium	1	
	chloride	1	
	S is iron(III)	1	
	sulfate	1	
10.2	$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$	1	
	$[Fe(H_2O)_6]^{3+}(aq) + 3OH^-(aq) \longrightarrow Fe(H_2O)_3(OH)_3(s) + 3H_2O(l)$	1	
	$2[Fe(H_2O)_6]^{3+}(aq) + 3CO_3^{2-}(aq) \longrightarrow 2Fe(H_2O)_3(OH)_3(s) + 3H_2O(l) + 3CO_2(g)$	1	
	$[Fe(H_2O)_6]^{3+}(aq) + 4Cl^-(aq) \longrightarrow [FeCl_4]^-(aq) + 6H_2O(l)$	1	