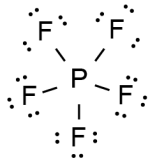
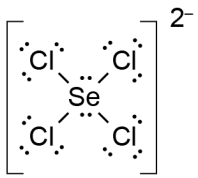
Assessment Schedule – 2024

Chemistry: Demonstrate understanding of thermochemical principles and the properties of particles and substances (91390)

Evidence Statement

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE (a)	 trigonal bipyramidal  square planar	• TWO correct.	• All correct.	
(b)(i)	$3N_2H_4(\ell) + 3O_2(g) \rightarrow 3N_2(g) + 6H_2O(\ell)$ -623×3 $4ClF_3(g) + 4NH_3(g) \rightarrow 12HF(g) + 2N_2(g) + 2Cl_2(g)$ -1200×2 $2N_2(g) + 6H_2O(g) \rightarrow 4NH_3(g) + 3O_2(g)$ (reverse) $+1270$ $6H_2O(\ell) \rightarrow 6H_2O(g)$ $+40.7 \times 6$ $\Delta_r H = -1869 + -2400 + 1270 + 244.2 = -2754.8 = -2750$ kJ mol^{-1}	• Recognises the need to multiply values.	• Correct process with one error.	• Correct answer with unit and significant figures (accept 2–4).
(ii)	The entropy of the system increases since 4 highly randomised, disordered gaseous molecules and 3 more ordered liquid molecules produce 17 highly randomised, disordered gaseous molecules. So, there is greater dispersal of matter and energy in the system. Since the reaction is exothermic (reaction is explosive), heat energy is released into the surroundings, so the particles in the surroundings gain heat energy / kinetic energy. As a result, there is greater dispersal of matter and energy in the surroundings, so the entropy of the surroundings increases. The increase in entropy of the system and of the surroundings makes the overall entropy change positive, so the reaction is spontaneous.	• Recognises that entropy is measure of dispersal of energy / matter / disorder. • Recognises that the entropy of the system increases due to the increase in moles/states change. • Recognises that the entropy of the surroundings increases because the reaction is exothermic/explosive.	• Explains entropy change for system. OR Explains entropy change for surroundings.	• Full justification of why the process is spontaneous.

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

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
TWO (a)(i)	3: third energy level / third electron shell p: the orbitals / subshell occupied 6: there are a total of six electrons in the p orbitals / subshell.	• TWO correct.		
(ii)	Ne > Ar > P	• Correct order.		
	Phosphorus and argon are in the same period. Ionisation energy increases across a period. Although the valence electron to be removed is in the same energy level, with the same repulsion / shielding from inner energy levels, the number of protons increases across a period. This means the electrostatic attraction between the positive nucleus and the valence electrons increases across a period, so Ar has a higher first ionisation energy than P. Neon and argon are in the same group. Ionisation energy decreases down a group because the valence electron to be removed is in an energy level further from the nucleus with greater repulsion / shielding from inner energy levels. Although the number of protons increases down a group, this effect is offset by the increasing distance between the nucleus and the valence electron to be removed. This means the electrostatic attraction between the positive nucleus and the valence electrons decreases down a group, so Ne has a higher first ionisation energy than Ar.	• Recognises one factor influencing ionisation energy trend.	• Explains 1st ionisation energy trend with reference to at least TWO of: energy levels, number of protons, repulsion from inner energy levels, strength of electrostatic attraction.	• Justifies the difference in first IE for all THREE elements.
(b)	There is an electronegativity difference between Br and Cl, so the Br–Cl bonds are polar covalent. There are five areas of electron density around the central Br atom, including three bond pairs and two lone pairs / non-bonding pairs. In the trigonal planar shape, the bond dipoles are arranged symmetrically around the central Br atom (due to lone pairs occupying axial positions), so the bond dipoles cancel out to make $BrCl_3$ a non-polar molecule. In contrast, the T-shaped arrangement has the bond dipoles arranged asymmetrically around the central Br atom (due to lone pairs occupying equatorial positions). As a result, the bond dipoles reinforce / add together / do not cancel out to make $BrCl_3$ a polar molecule.	• Identifies the correct polarity of each shape. • Recognises the polarity of the Br–Cl bond due to the difference in electronegativity.	• In a trigonal planar shape, the Br–Cl dipoles would cancel out as they are symmetrically arranged. • In a T-shaped molecule, the Br–Cl dipoles would not cancel out, as they are asymmetrically arranged (due to the presence of lone pairs in equatorial positions).	• Compares the polarity of both shapes of $BrCl_3$, with reference to bond polarity and the arrangement of bond dipoles.

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

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
THREE (a)(i)	NH_3: Hydrogen bonding, (permanent dipole), temporary dipole SO_2: Permanent dipole, temporary dipole C_5H_{12}: Temporary dipole	• TWO rows correct.		
(ii)	Due to the large electronegativity difference between H and N, there is strong hydrogen bonding between NH_3 molecules. This is stronger than the permanent dipole attractions between the polar SO_2 molecules. However, SO_2 is a larger molecule than NH_3, with a larger electron cloud. This means SO_2 has stronger / more temporary dipole attractions between the SO_2 molecules, and therefore a higher boiling point.	• Recognises hydrogen bonding is stronger than permanent /temporary dipole attractions.	• Explains why SO_2 has the higher boiling point by linking the larger electron cloud to stronger / more temporary dipole attractions.	• Justifies difference in boiling points for ALL three molecules in terms of strength of attractive forces.
(iii)	Despite the molecules having quite similar-sized e^- clouds (molar mass), pentane has stronger intermolecular attractions. Pentane is a longer molecule when compared to the more spherical shape of polar SO_2, so it has a greater surface area for interaction, meaning stronger temporary dipole attractions. Even though there are strong permanent dipole attractions between the polar SO_2 molecules, more energy is needed to break the attractions between the pentane molecules, so pentane has a higher boiling point.	• Recognises that molar mass / e-cloud size affects temporary dipole attractions /boiling point. • Recognises that chain length /surface area affects temporary dipole attractions/ boiling point.	• Explains that the linear shape / greater surface area of pentane means stronger attractive forces despite the permanent dipoles /polar nature of SO_2.	
(b)(i)	$n(C_2H_5OH) = \frac{m}{M} - \frac{0.500}{46.0} = 0.0109$ mol $-q = \Delta_r H \times n = -770 \times 0.0109 = -8.37$ kJ Therefore $q = 8.37$ kJ $= 8370$ J $m = \frac{q}{c\Delta t} = \frac{8370}{4.18 \times 9.1} = 220$ g	• One step of calculation correct.	• Correct process for calculation with one error.	• Correct final mass, including unit and significant figures (accept 2 – 4 significant figures for final answer).
(ii)	Identifies temperature change of water. The temperature change (rise) as beaker is not insulated / no lid / heat escaping round the sides, therefore less heat is transferred to the water than should be. Heat loss to the gauze (and beaker), therefore less heat is transferred to the water than should be.	• Identifies temperature change of water and states ONE reason.	• Identifies temperature change of water and explains ONE reason.	

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

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 06	07 – 13	14 – 18	19 – 24