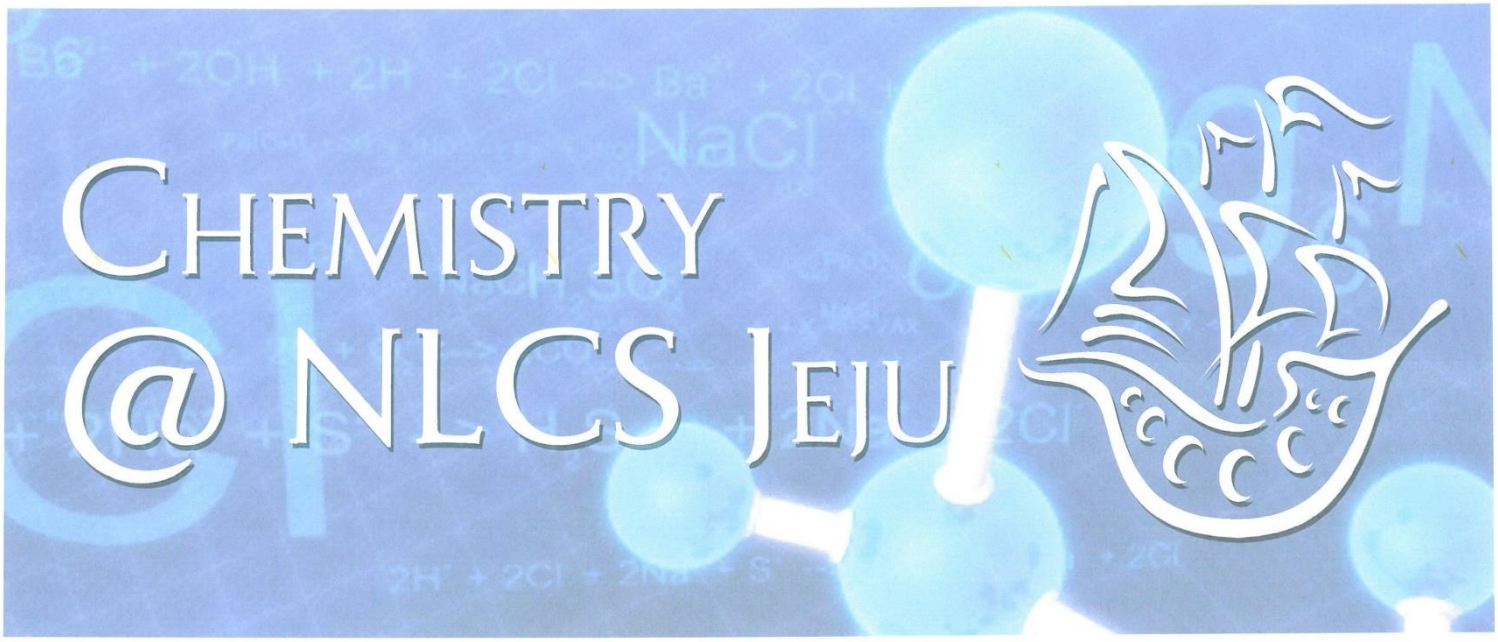
Topic 3

STANDARD Level



Summer & Winter Papers

Summer 1999 to Summer 2013

Name:_____

Topic Exam Statistics (Paper 2):

Section	Marks	% of All Marks	Last four exams marks	Last four exams %
A	52/810	**6%**	/120	%
B	188/1620	**12%**	/240	%
TOTAL	240/2430	**10%**	/360	%

Total number of papers represented here is 27, each with 30 marks of Section A and 60 marks of section B (3 questions from which you choose to answer only 1)

SL SECTION A 13s

TABLE 8

2. Table 8 of the Data Booklet shows the atomic and ionic radii of the elements.

(a) Describe and explain the trend in atomic radius across period 3. *[3]*

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(b) A student formulates the following hypothesis: "If phosphorus were to form a positive ion, P^{3+}, its ionic radius would probably be between 110×10^{-12} m and 212×10^{-12} m." Evaluate this hypothesis. *[2]*

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SL SECTION A 07s

2. (a) State the meaning of the term *electronegativity.* *[1]*

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(b) State and explain the trend in electronegativity across period 3 from Na to Cl. *[2]*

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(c) Explain why Cl_2 rather than Br_2 would react more vigorously with a solution of I^-. *[2]*

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SL SECTION A 05w

4. (a) (i) Define the term *ionization energy.* *[2]*

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(ii) Write an equation, including state symbols, for the process occurring when measuring the first ionization energy of aluminium. *[1]*

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(b) The first ionization energies of the elements are shown in Table 7 of the Data Booklet. Explain why the first ionization energy of magnesium is greater than that of sodium. *[2]*

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(c) Lithium reacts with water. Write an equation for the reaction and state **two** observations that could be made during the reaction. *[3]*

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SL SECTION A 03s

4. Explain the following statements.

(a) The first ionization energy of sodium is

(i) less than that of magnesium. *[2]*

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(ii) greater than that of potassium. *[1]*

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(b) The electronegativity of chlorine is higher than that of sulfur. *[2]*

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SL SECTION A 03s

5. The element vanadium has two isotopes, $^{50}_{23}V$ and $^{51}_{23}V$, and a relative atomic mass of 50.94.

(a) Define the term *isotope*. *[1]*

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. . . . . .

(b) State the number of protons, electrons and neutrons in $^{50}_{23}V$. *[2]*

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. . . . . .

(c) State and explain which is the more abundant isotope. *[1]*

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. . . . . .

(d) State the name and the mass number of the isotope relative to which **all** atomic masses are measured. *[1]*

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SL SECTION A 02s

1. The values of atomic radius and ionic radius for the period 3 elements are given below.

Symbol of element	Na	Mg	Al	Si	P	S	Cl
Atomic radius / 10^{-12} m	186	160	143	117	110	104	99
Ionic radius / 10^{-12} m	98	65	45	42	212	190	181

(a) Complete the following table to show the number of protons and electrons in **each** of the following species: *[3]*

	Number of protons	**Number of electrons**
Na	.....	.....
Al^{3+}	.....	.....
P^{3-}	.....	.....

(b) Explain why the **atomic** radius decreases from sodium to chlorine. *[2]*

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(c) The ionic radius of aluminium is smaller than its atomic radius. The ionic radius of phosphorus is greater than its atomic radius. Explain the large difference in ionic radius between aluminium and phosphorus. *[2]*

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(d) Sodium and chlorine both react with water.

(i) Write an equation for the reaction between sodium and water and state whether the resulting solution is acidic, neutral or alkaline. *[2]*

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(ii) Write an equation for the reaction between chlorine and water and state whether the resulting solution is acidic, neutral or alkaline. *[2]*

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SL SECTION A 01w

3. (a) Boron and aluminium are in the same group in the periodic table. Based on their electron configurations, explain why the first ionisation energy of boron is greater than that of aluminium. *[2]*

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(b) Aluminium and silicon are in the same period. Explain why the first ionisation energy of silicon is greater than that of aluminium. *[2]*

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SL SECTION A 00s

2. (a) Define, in words or with an equation, the first ionisation energy of Na. *[2]*

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(b) State how the first ionisation energy varies down group 1. *[1]*

. . . . . .

(c) Li, Na and K react with water. Which of the three reactions will be the most vigorous? Explain this at an atomic level. *[2]*

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(d) State whether the second ionisation energy of sodium is less than, the same as, or greater than the first ionisation energy. Explain your answer. *[2]*

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SL B 12wQ4a

(ii) Distinguish between the terms *group* and *period*. *[1]*

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SL B 12sQ6f

(iii) The reactions between the halogens and water show that fluorine is more reactive than bromine. Explain why, on an atomic level, fluorine is the more reactive element. *[3]*

SL B 11wQ5

(b) Describe the acid-base character of the oxides of the period 3 elements, Na to Cl. For the compounds sodium oxide and phosphorus(V) oxide, state the balanced chemical equations for the reaction of each oxide with water. *[4]*

SL B 11s

5. (a) (i) Define the term *first ionization energy*. *[2]*

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(ii) Explain why the first ionization energy of magnesium is higher than that of sodium. *[2]*

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(b) Explain why:

(i) calcium has a higher melting point than potassium. *[2]*

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(ii) sodium oxide has a higher melting point than sulfur trioxide. *[3]*

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SL B 11s

7. Carbon and silicon belong to the same group of the periodic table.

(a) Distinguish between the terms *group* and *period* in terms of electron arrangement. *[2]*

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. . . . . .
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(b) State the period numbers of both carbon and silicon. *[1]*

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. . . . . .

SL B 10sQ4

(e) State a balanced equation for the reaction of sodium with water. Include state symbols. *[2]*

(f) With reference to electronic arrangements, suggest why the reaction between rubidium and water is more vigorous than that between sodium and water. *[2]*

(g) Describe and explain what you will see if chlorine gas is bubbled through a solution of

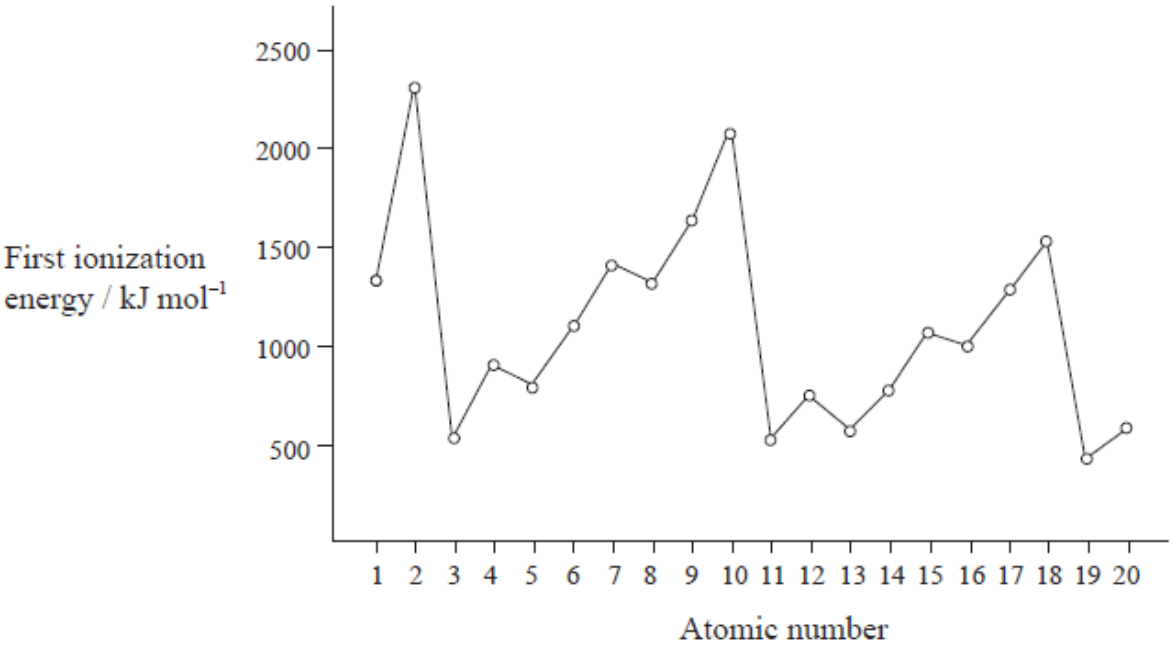
(i) potassium iodide. *[2]*

(ii) potassium fluoride. *[1]*

(h) Explain why the melting points of the elements decrease down group 1 and increase down group 7. *[4]*

SL B 09sQ5

(b) The graph of the first ionization energy plotted against atomic number for the first twenty elements shows periodicity.



(i) Define the term *first ionization energy* and state what is meant by the term *periodicity*. *[2]*

(ii) State the electron arrangement of argon and explain why the noble gases, helium, neon and argon show the highest first ionization energies for their respective periods. *[3]*

(iii) A graph of atomic radius plotted against atomic number shows that the atomic radius decreases across a period. Explain why chlorine has a smaller atomic radius than sodium. *[1]*

(iv) Explain why a sulfide ion, S^{2-}, is larger than a chloride ion, Cl^{-}. *[1]*

(v) Explain why the melting points of the Group 1 metals (Li → Cs) decrease down the group whereas the melting points of the Group 7 elements (F → I) increase down the group. *[3]*

SL B 08sQ6

(c) The oxides of magnesium, aluminium and phosphorus illustrate the change in nature of elements from metallic to non-metallic. Each of the three oxides is mixed with separate samples of pure water. For each of the oxides, state whether the **resulting solution** is acidic, basic or neutral. Write an equation for each reaction that occurs. *[4]*

SL B 07w

6. (a) (i) Define the term *ionization energy*. *[1]*

(ii) Write an equation for the reaction of lithium with water. *[1]*

(iii) State and explain the trend in the ionization energy of alkali metals down the group. *[3]*

(iv) Explain why the electronegativity of phosphorus is greater than that of aluminium. *[2]*

(v) Table 8 in the Data Booklet contains two values for the ionic radius of silicon. Explain, by reference to atomic structure and electron arrangements, why the two values are very different. *[4]*

SL B 06w

DBTB BOOKLET

4. Information about the halogens appears in the Data Booklet.

(a) (i) Explain why the ionic radius of chlorine is less than that of sulfur. *[2]*

(ii) Explain what is meant by the term *electronegativity* and explain why the electronegativity of chlorine is greater than that of bromine. *[3]*

(b) For each of the following reactions in aqueous solution, state **one** observation that would be made, and deduce the equation.

(i) The reaction between chlorine and sodium iodide. *[2]*

(ii) The reaction between silver ions and chloride ions. *[2]*

SL B 06s

7. (a) Explain why

(i) the first ionization energy of magnesium is lower than that of fluorine. *[2]*

(ii) magnesium has a higher melting point than sodium. *[3]*

(b) Discuss the acid-base nature of the period 3 oxides. Write an equation to illustrate the reaction of one of these oxides to produce an acid, and another equation of another of these oxides to produce a hydroxide. *[5]*

SL B 05s

7. (a) State and explain the trends in the atomic radius and the ionization energy

(i) for the alkali metals Li to Cs. *[4]*

(ii) for the period 3 elements Na to Cl. *[4]*

(b) (i) Describe **three** similarities and **one** difference in the reactions of lithium and potassium with water. *[4]*

(ii) Give an equation for **one** of these reactions. Suggest a pH value for the resulting solution, and give a reason for your answer. *[3]*

(c) Classify each of the following oxides as acidic, basic or amphoteric.

(i) aluminium oxide *[1]*
(ii) sodium oxide *[1]*
(iii) sulfur dioxide *[1]*

(d) Write an equation for each reaction between water and

(i) sodium oxide. *[1]*
(ii) sulfur dioxide. *[1]*

SL B 04w

TABLE 8

6. (a) Nitrogen is found in period 2 and group 5 of the periodic table.

(i) Distinguish between the terms *period* and *group*. *[1]*

(ii) State the electron arrangement of nitrogen and explain why it is found in period 2 and group 5 of the periodic table. *[3]*

(b) Table 8 of the Data Booklet gives the atomic and ionic radii of elements. State and explain the difference between

(i) the atomic radius of nitrogen and oxygen. *[2]*

(ii) the atomic radius of nitrogen and phosphorus. *[1]*

(iii) the atomic and ionic radius of nitrogen. *[2]*

SL B 03w

TABLE 6

6. (a) Describe the acid-base character of the oxides of the period 3 elements Na to Ar. For sodium oxide and sulfur trioxide, write balanced equations to illustrate their acid-base character. *[4]*

(b) Table 6 of the Data Booklet lists melting points of the elements. Explain the trend in the melting points of the alkali metals, halogens and period 3 elements. *[8]*

(c) (i) Explain how the first ionization energy of K compares with that of Na and Ar. *[3]*

(ii) Explain the difference between the first ionization energies of Na and Mg. *[4]*

(iii) Suggest why much more energy is needed to remove an electron from Na^+ than from Mg^+. *[1]*

SL B 02w

4. (a) The first ionisation energies of the elements are given in Table 7 of the Data Booklet.

(i) Define the term *first ionisation energy*. *[1]*

(ii) State and explain the trend in first ionisation energy values across the period Li to F. *[3]*

(iii) State and explain the trend in first ionisation energy values down group 1, Li to Cs. *[3]*

(b) Give a formula for a stable oxide of each of the elements Na to S and comment on their acid-base nature. *[6]*

SL B 02w

TABLE 6 AND 7

(c) Table 7 in the Data Booklet also gives the electronegativities of the elements.

(i) Define the term *electronegativity*. *[1]*

(ii) Predict the type of bonding formed between Ca and S and explain your answer with reference to electronegativity values. *[2]*

(d) Table 6 in the Data Booklet gives the melting points of the elements. State the type of bonding present and explain the difference in melting point in each of the following pairs. *[4]*

(i) Sodium and magnesium

(ii) Chlorine and argon

SL B 01sQ5

(b) (i) Explain **each** of the terms *ionisation energy* and *electronegativity*. *[5]*

(ii) Give the equation for the reaction of potassium with water and explain why potassium is more reactive than lithium. *[4]*

(c) Describe and explain the trends in atomic radii **and** electronegativity on descending the halogen group and across Period 3. *[6]*

SL B 00wQ5

(d) (i) Trends in atomic radii of elements are given in Table 8 of the Data Booklet. Account for the trend in atomic radii of the halogens (F → At) and the period 2 elements (Li → Ne). *[4]*

(ii) Write the equation for the first ionisation of magnesium, including the states. With reference to its electronic configuration, account for the ionisation energy values for magnesium in the table below:

Energy (kJ mol^{-1}) required to remove:		
1st electron	2nd electron	3rd electron
740	1450	7740

[4]

SL B .99w

6. Account for the following observations on the atomic/ionic/molecular level.

(a) The melting points of chlorine, sodium and silicon increase in the order $Cl_2 < Na < Si$. *[5]*

(b) The radii of a potassium atom, a chloride ion, an atom of argon and a potassium ion are in the order $K > Cl^- > Ar > K^+$. *[5]*

(c) The chemical reactions of the oxides of sodium, Na_2O, aluminium, Al_2O_3, and sulfur, SO_2, can be used to illustrate the change from metallic to non-metallic properties across Period 3 (Na–Ar) of the Periodic Table. *[5]*

(d) The first ionisation energy (IE) of sodium is lower than the first ionisation energy of magnesium. The second ionisation energies of sodium and magnesium are higher than their respective first ionisation energies. The second ionisation energy of sodium is higher than the second ionisation energy of magnesium.

That is: IE Na^+ > IE Mg^+ > IE Mg > IE Na *[5]*

SL B .99SQ4

(c) For the three elements Na, K and Cl, state, with a reason in each case, which pair is in the same group and which pair is in the same period of the Periodic Table. *[4]*

IB SL 3 EQ Paper 2 s99 to s13 incl W Mark Scheme

SL SECTION A 13s

2. (a) decreases (from left to right/across period 3);
same number of shells/energy levels / shielding effect remains the same;
number of protons/nuclear charge increases so attraction of nucleus on outer electrons increases / *OWTTE*; *[3]*

(b) hypothesis is wrong since ionic radius should be smaller than atomic radius/110×10^{-12} m;
greater attraction of the nucleus on outer electrons / effective charge of nucleus greater / repulsive forces between electrons smaller; *[2]*

SL SECTION A 07s

2. (a) the ability of an element/atom/nucleus to attract a bonding pair of electrons; ***[1]***

(b) electronegativity increases (along period 3 from Na to Cl);
number of protons increases / nuclear charge increases / core charge increases / size of atoms decreases; ***[2]***
Do not accept greater nuclear attraction.

(c) Cl_2 is a stronger oxidizing agent / Chlorine's outer shell closer to nucleus;
Cl_2 has greater attraction for electrons / has a higher electron affinity; ***[2]***
Accept converse argument for Br_2.

SL SECTION A 05w

4. (a) (i) the (minimum) energy required/needed for the removal of one electron;
from a gaseous/isolated atom; ***[2]***

(ii) $Al(g) \rightarrow Al^{+}(g) + e$; ***[1]***
Do not penalize the answer if (g) is after e.

(b) greater nuclear charge / greater number of protons / atom radius g is smaller;
stronger attraction (for electron); ***[2]***

(c) $2Li + 2H_2O \rightarrow 2LiOH + H_2$;
Ignore state symbols.

effervescence/fizzing/bubbles/*OWTTE*;
lithium moves around/decrease in size of piece;
Accept dissolves or disappears.
heat produced; ***[3 max]***
*Award **[1]** each for any two of last three observations.*

SL SECTION A 03s

4. (a) (i) Na has lower nuclear charge / number of protons;
electrons being removed are from same energy level / shell;
or Na has larger radius / electron further from nucleus; ***[2 max]***
Award this mark if both electron arrangements are given.

(ii) Na electron closer to nucleus / in lower energy level / Na has less shielding effect; ***[1]***
Allow counter arguments for Mg in (i) and K in (ii).

(b) chlorine has a higher nuclear charge;
attracts the electron **pair** / electrons in bond more strongly; ***[2]***

SL SECTION A 03s

5. (a) atom of same element / same number of protons but with different mass number / number of neutrons; ***[1]***

(b) protons 23
electrons 23
neutrons 27
*Three correct **[2]**, two correct **[1]**.* ***[2]***

(c) $^{51}_{23}V$ / 51 nearer to A_r value of 50.94; ***[1]***

(d) carbon, 12 / ^{12}C; ***[1]***

SL SECTION A 02s

1. (a) Na 11 protons and 11 electrons ***[1]***;
Al^{3+} 13 protons and 10 electrons ***[1]***;
P^{3-} 15 protons and 18 electrons ***[1]***. ***[3]***

(b) *(Award **[1]** for any two from the following:)*

increasing proton number / nuclear charge ***[1]***;
electrons attracted more strongly to nucleus ***[1]***;
electrons in same shell / energy level / no change in shielding ***[1]***. ***[2]***

(c) Al loses electrons, P gains electrons (*allow equations*) ***[1]***;
phosphide/phosphorus has one more shell / energy level than aluminium ***[1]***. ***[2]***
Allow 2.8 and 2.8.8 for second mark.

(d) (i) $2Na + 2H_2O \rightarrow 2NaOH + H_2$ ***[1]***;
alkaline ***[1]***; ***[2]***

(i) $Cl_2 + H_2O \rightarrow HCl + HClO$ ***[1]***;
acidic ***[1]***. ***[2]***

SL SECTION A 01w

3. (a) B: 2.3; Al: 2.8.3 *(need both for mark)* ***[1]***
Electron being removed in Al is in $n = 3$ / further away from the nucleus and easier to remove. ***[1]***

(b) Valence electron in Si is in the same main energy level. ***[1]***
Greater nuclear charge holds valence electrons more tightly. ***[1]***
(Thus needs more energy to remove electron.)

SL SECTION A 00s

2. (a) Either: remove one electron ***[1]***
gaseous/free atoms ***[1]***

Or: $\underline{Na\,(g)} \rightarrow \underline{Na^+\,(g)} + \underline{e^-}$ (or e) ***[2]***

*(Deduct **[1 mark]** for each underlined term omitted.)*

(b) Decreases. ***[1]***

(c) K ***[1]***

Outer electron is furthest from the nucleus/it has the lowest IE/outer electron is least strongly attracted. ***[1]***

(d) Greater/higher ***[1]***
Second electron is nearer to the nucleus/in a lower energy level, more difficult to remove. ***[1]***

SL B 12wQ4a

(ii) *Group*: (elements in vertical) columns in periodic table **and** *Period*: (elements in horizontal) rows in periodic table; ***[1]***

*Allow elements in same group have similar chemical properties **and** within a period, atoms have same number of shells/energy levels (but number of electrons in valence/outer shell increases).*

*Allow groups distributed vertically **and** periods distributed horizontally / OWTTE.*

*Allow group number gives number of valence/outer shell electrons (for main-group elements) **and** period gives same number of shells/energy levels.*

SL B 12sQ6f

(iii) fluorine accepts/attracts electrons more readily/strongly / is a better oxidizing agent;

fluorine has smaller atomic radius/fewer energy levels/shells;

Do not allow fluorine atom smaller.

so nucleus attracts electrons more strongly; ***[3]***

Allow opposite argument for bromine.

SL B 11wQ5

(b) *Na*, *Mg*: basic

Al: amphoteric

Do not accept amphiprotic.

Si to Cl: acidic

*Award **[2]** for all three listed sets correct, **[1]** for one or two listed sets correct.*

*Award **[1]** for stating oxides become more basic towards left/Na and more acidic towards right/Cl.*

Do not penalize incorrect formulas of oxides.

$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$;

$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$; ***[4]***

Ignore state symbols.

Allow $P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$.

SL B 11s

5. (a) (i) the amount of energy required to remove one (mole of) electron(s);
from (one mole of) an atom(s) in the gaseous state; *[2]*

(ii) greater positive charge on nucleus / greater number of protons / greater core charge;
greater attraction by Mg nucleus for electrons (in the same shell) / smaller atomic radius; *[2]*

(b) (i) calcium ionic charge is twice/greater than the potassium ionic charge / calcium has more delocalized electrons than potassium;
greater attraction of delocalized electrons and Ca^{2+} / less attraction between the delocalized electrons and K^{+}; *[2]*
Do not accept calcium ion has a 2^{+} without comparison to K^{+}.

(ii) Na_2O ionic/(stronger electrostatic) attractions between Na^{+} and O^{2-};
SO_3 has (weak) intermolecular/van der Waals'/London/dispersion/dipole-dipole attractions;
intermolecular/van der Waals'/London/dispersion/dipole-dipole forces are weaker/more easily broken than (strong) ionic bonds / ionic bonds are stronger/harder to break than intermolecular bond/van der Waals'/London/dispersion/dipole-dipole forces; *[3]*

SL B 11s

7. (a) *Group*: number of outershell/valence electrons;
Period: number of occupied (electron) shells; *[2]*

(b) C: 2 **and** Si: 3; *[1]*

SL B 10sQ4

(e) $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$ / $Na(s) + H_2O(l) \rightarrow NaOH(aq) + \frac{1}{2}H_2(g)$ *[2]*
Award [1] for correct balanced equation.
Award [1] for correct state symbols for sodium, water, sodium hydroxide and hydrogen.
Second mark is not dependent on equation being correctly balanced.

(f) (Rb more reactive because) electron lost further from nucleus so less tightly held;
Rb electron is in 5th energy level **and** (Na less reactive) as electron lost in 3rd energy level / *OWTTE*; *[2]*
Allow [1 max] for electron arrangements of Na (e.g. 2,8,1) and Rb if second mark is not scored.

(g) (i) solution becomes yellow/orange/brown/darker;
chlorine is more reactive than iodine (and displaces it from solution) / *OWTTE*; *[2]*
Allow correct equation ($2KI + Cl_2 \rightarrow 2KCl + I_2$) for second mark or stating that iodine/I_2 is formed.

(ii) no colour change/nothing happens as fluorine is more reactive than chlorine / *OWTTE*; *[1]*

(h) *Down group 1:*
metallic bonding gets weaker;
radii/atoms get bigger / delocalized electrons shielded/screened from nucleus by filled shells;

Down group 7:
increased M_r of halogen molecules / *OWTTE*;
intermolecular/van der Waals/London/dispersion forces increase; *[4]*

SL B 09sQ5

(b) (i) first ionization energy: $M(g) \rightarrow M^+(g) + e^-$/e / the (minimum) energy (in kJ mol^{-1}) to remove one electron from a gaseous atom / the energy required to remove one mole of electrons from one mole of gaseous atoms;
periodicity: repeating pattern of (physical and chemical) properties; ***[2]***

(ii) 2.8.8/sp version;

Accept any two of the following:
the outer energy level/shell is full;
the increased charge on the nucleus;
great(est) attraction for electrons; ***[3 max]***

(iii) 17 p in Cl nucleus attract the outer level more than 11 p in Na nucleus / greater nuclear charge attracts outer level more; ***[1]***
Allow converse for Na.
Do not accept larger nucleus.

(iv) S^{2-} has one proton less/ smaller nuclear charge so outer level held less strongly / *OWTTE*; ***[1]***
Allow converse for chloride.
Do not accept larger nucleus.

(v) the radii of the metal atoms increase (from $Li \rightarrow Cs$) (so the forces of attraction are less between them) / *OWTTE*;
the forces of attraction between halogen molecules are van der Waals;
forces increase with increasing mass/number of electrons; ***[3]***

SL B 08sQ6

(c) (MgO) basic **and** (P_4O_6 / P_4O_{10}) acidic;
(Al_2O_3) neutral;
Formulas not required but it must be clear which oxide is being referred to

$MgO + H_2O \rightarrow Mg(OH)_2$;
$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$; ***[4]***
Accept suitable equation with P_4O_6 / P_2O_5 / P_2O_3.

SL B 07w

6. (a) (i) minimum energy required to remove one (mole of) electron(s) from (one mole of) (a) gaseous atom(s) / *OWTTE*; ***[1]***

(ii) $2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g) / Li(s) + H_2O(l) \rightarrow LiOH(aq) + 1/2H_2(g)$; ***[1]***
State symbols not required

(iii) (ionization energy) decreases;
radius increases / valence electrons further away from nucleus / electron removed from higher shell;
(nuclear charge increases but) shielding/screening effect increases / more electrons between nucleus and valence electron / lower effective nuclear charge/ Z_{eff}; ***[3]***

(iv) phosphorus has a higher (effective) nuclear charge/Z_{eff};
radius of P is smaller;
electron pair/bonding electrons attracted more strongly; ***[2 max]***

(v) both have same number of protons/14 protons/nuclear charge/core charge;
Si^{4+} formed by electron loss, Si^{4-} formed by electron gain;
Si^{4+} : 2.8 arrangement / 2 (complete) energy levels / electrons in n = 2;
Si^{4-} : 2.8.8 arrangement / 3 (complete) energy levels / electrons in n = 3;
explanation of proton : electron ratio;
higher effective nuclear charge/Z_{eff} in Si^{4+}; ***[4 max]***

SL B 06w

4. (a) (i) (chlorine has) an extra proton/more protons/greater nuclear charge / 17+ compared to 16+;
outer electrons attracted more strongly; ***[2]***

(ii) ability of atom to attract bonding pair of electrons / electrons in a covalent bond ;
chlorine has a smaller radius / (electrons) closer to nucleus / in lower energy level;
repelled by fewer inner electrons / decreased shielding effect; ***[3]***

(b) (i) orange/brown solution;
$Cl_2 + 2NaI \rightarrow I_2 + 2NaCl / Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$; ***[2]***

(ii) (white) precipitate/solid formed;
$Ag^+ + Cl^- \rightarrow AgCl$; ***[2]***

SL B 06s

7. (a) (i) electron removed from higher energy level / further from nucleus / greater atomic radius;
increased repulsion by extra inner shell electrons / increased shielding effect; ***[2]***

(ii) Mg has twice as many / more delocalized electrons (compared to Na);
the ionic charge is twice as big / greater in Mg (than Na);
(electrostatic) attraction between ions and electrons is much greater; ***[3]***

(b) oxides of Na, Mg are basic
Al is amphoteric
Si, P, S and Cl are acidic
*Award 7 correct **[3]**, 6/5 correct **[2]** and 4/3 correct **[1]**.*

$SO_2 + H_2O \rightarrow H_2SO_3$ / $SO_3 + H_2O \rightarrow H_2SO_4$ /
$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ / $P_4O_6 + 6H_2O \rightarrow 4H_3PO_3$;
$Na_2O + H_2O \rightarrow 2NaOH$ / $MgO + H_2O \rightarrow Mg(OH)_2$; ***[5]***
Accept equation using P_2O_3 or P_2O_5.

SL B 05s

7. (a) (i) *Li to Cs*
atomic radius increases;
because more full energy levels are used or occupied / outer electrons further from nucleus / outer electrons in a higher shell;
ionization energy decreases;
because the electron removed is further from the nucleus / increased repulsion by inner-shell electrons; ***[4]***
Accept increased shielding effect.

(ii) *Na to Cl*
atomic radius decreases;
because nuclear charge increases **and** electrons are added to same main (outer) energy level;
ionization energy increases;
because nuclear charge increases **and** the electron removed is closer to the nucleus/is in the same energy level; ***[4]***
Accept "core charge" for "nuclear charge".
In (i) and (ii) explanation mark dependent on correct trend.

(b) (i) *similarities **[3 max]***
the metal floats / moves on the surface;
fizzing / effervescence / bubbles; (*accept sound is produced*)
solution gets hot;
solution becomes alkaline / basic;
they react to form the metal hydroxide;
hydrogen is evolved;

*differences **[1 max]***
flame / hydrogen burns with potassium (and not with lithium) / reaction faster / more vigorous with potassium / slower or less vigorous with lithium; ***[4 max]***

(ii) $2Li + 2H_2O \rightarrow 2Li^+ + 2OH^- + H_2$ / $2K + 2H_2O \rightarrow 2K^+ + 2OH^- + H_2$;
Accept LiOH / KOH.
pH ⩾ 11;
LiOH/KOH is a strong base/strong alkali / high concentration of OH^-; ***[3]***

(c) (i) *aluminium oxide*
amphoteric;

(ii) *sodium oxide*
basic;

(iii) *sulfur dioxide*
acidic; ***[3]***

(d) (i) $Na_2O + H_2O \rightarrow 2Na^+ + 2OH^-$;
(ii) $SO_2 + H_2O \rightarrow H_2SO_3$; ***[2]***
Accept NaOH and $H^+ + HSO_3^-$ / $2H^+ + SO_3^{2-}$.

SL B 04w

6. (a) (i) period is a horizontal row in the periodic table and a group is a vertical column / *OWTTE*; ***[1]***

(ii) 2,5;
electrons in two energy levels / shells;
five outer / valence electrons; ***[3]***

(b) (i) atomic radius of N > O because O has greater nuclear charge;
greater attraction for the outer electrons / *OWTTE*; ***[2]***

(ii) atomic radius of P > N because P has outer electrons in an energy level further from the nucleus / *OWTTE*; ***[1]***

(iii) N^{3-} > N / ionic radius > atomic radius because N^{3-} has more electrons than protons;
so the electrons are held less tightly / *OWTTE*; ***[2]***
*Award **[1]** for greater repulsion in N^{3-} due to more electrons (no reference to protons).*

SL B 03w

6. (a) oxides of: Na, Mg: basic;
Al: amphotoric;
Si to Cl: acidic;
Ar: no oxide;
*All four correct **[2]**, two or three correct **[1]**.*

$Na_2O + H_2O \rightarrow 2NaOH$;
$SO_3 + H_2O \rightarrow H_2SO_4$;
Must be balanced for marks.
Award mark for alternative correct equations such as SO_3 with NaOH. ***[4]***

(b) *alkali metals:*
metallic bonding / a bed of cations in a sea of electrons;
as radius increases down the group, valence electrons are further away from nucleus (and strength of metallic bonding decreases);

halogens:
non-polar / van der Waal's forces between molecules;
as size increases van der Waal's forces increase (and melting point increases);

period 3 elements:
increase in melting points of metals (Na, Mg, Al) due to increase in number of valence electrons **and** decrease in size / the way atoms are packed as solids;
Award mark just for "increased number of delocalized or valence electrons".

silicon:
network covalent solid (with very high melting point);
Award mark also for "many or strong covalent bonds".
[8]

$P \rightarrow Ar$:
simple molecular (atomic in case of Ar) substances with weak van der Waal's forces (and lower melting points);
trend in P_4, S_8, Cl_2, Ar due to size / mass of particles;
Award mark for "decreasing mass or size".
Molecular formulae not necessary.

(c) *(i) and (ii) marked together.*

K less than Na because
electron removed (from K) is from higher energy level / further from nucleus / in n=4 compared to n= 3;
this is more important than the extra 8 protons in K / OWTTE;
increase repulsion by extra shell of electrons / greater shielding effect;
so less strongly attracted by nucleus;

K less than Ar because
electron removed (from K) is from higher energy level / further from nucleus / in n=4 compare to n = 3;
and has only one more proton;
increase repulsion by extra shell of electrons / greater shielding effect;
so less strongly attracted by nucleus;

Mg greater than Na because
(Mg has) greater nuclear charge / one more proton / 12 protons compare to 11;
electron removed is in same (main) higher energy level / shell;
smaller (atomic) radius;
so more strongly attracted by nucleus; ***[7]***

Accept opposite worded arguments, i.e. why Na is greater than K.
*Award **[7]** for any seven correct but accept less/more strongly attracted to nucleus once only.*

(iii) second electron in Na removed from n = 2, whereas second electron in Mg removed from n = 3 ***[1]***

SL B 02w

4. (a) (i) the energy required to remove an electron from a **gaseous** atom;
(do not award mark if any mention of electron gain) ***[1]***

(ii) I.E. increases along the period from Li to F;
electrons are being added to the same energy level / shell / orbital;
number of protons increases / nuclear charge increases / nuclear attraction increases / *OWTTE (allow atomic radius decreases)*; ***[3]***

(iii) I.E. decreases down the group from Li to Cs;
atomic radius increases / outer electron further from nucleus;
increasing shielding effect / weaker nuclear attraction / increased repulsion by inner electrons / *OWTTE*; ***[3]***

(b)

Na_2O	MgO	Al_2O_3	SiO_2	P_2O_3 / P_4O_6 / P_2O_5 / P_4O_{10}	SO_2 / SO_3
*Six correct = **[3]**, five/four correct = **[2]**, three/two correct = **[1]**.*					
basic	basic	amphoteric	acidic	acidic	acidic
*Six correct = **[3]**, five/four correct = **[2]**, three/two correct = **[1]**.*					

*If none of last three marks scored, award **[1]** for either basicity decreases or acidity increases across the period.*

SL B 02w

(c) (i) the tendency of an atom to attract an electron **pair** / bonding pair in a covalent bond / compound; ***[1]***

(ii) ionic;
large difference in (electronegativity) values / Ca has low electronegativity and S has high electronegativity / *OWTTE*;
(do not accept just the values quoted from the Data Booklet). ***[2]***

(d) (i) metallic;
Mg has more delocalized / free electrons (than Na);
(not just more outer or valence electrons).

(ii) van der Waals' forces / dispersion forces / London forces;
(ignore covalent bonding in Cl_2*)*
Cl_2 / has higher M_r / is a bigger molecule / chlorine is diatomic and argon is monatomic / *OWTTE*;
(do not award second mark if any reference to breaking of covalent bonds). ***[4]***

SL B 01s

(b) (i) Ionisation energy: (energy) required to remove one electron ***[1]***
from outermost shell ***[1]***
from gaseous atom ***[1]***
(Allow monatomic element but not gaseous element)

(Correct equation, with (g) indicated, could score ***[2]****)*

Electronegativity: tendency / ability / power to attract (not gain) electrons ***[1]***
of a shared pair / covalent bond ***[1]*** ***[5 max]***

(ii) $2K + 2H_2O \rightarrow 2KOH + H_2$ products correct ***[1]***
balanced ***[1]***

K bigger / e^- farther from the nucleus / K has more electron shells / increased shielding ***[1]***
e^- less strongly attracted / more easily lost ***[1]*** ***[4 max]***

(c) Halogens: electronegativity decreases down group ***[1]***
radius increases down group ***[1]***
shielding effect too ***[1]***
more shells ***[1]***

Period 3: electronegativity increases ***[1]***
radius falls ***[1]***
nuclear charge increases ***[1]***
electrons in same shell ***[1]***

[6 max]

SL B 00wQ5

(d) (i) Atomic radii: For halogens an increase because valence electrons are placed in successive energy levels *[1]*
further away from the nucleus. *[1]*
In period 3, radii decreases as electrons are placed in the **same** main energy level. *[1]*
Increased nuclear charge increases attraction for valence electrons (pulling them closer). *[1]*

(ii) $Mg(g) \rightarrow Mg^{+}(g) + e^{-}$ *[1]*

(Both state symbols needed.)

Once the first outer electron is removed, the second outer electron experiences more attraction / atom becomes more positively charged *[1]*

Third electron comes from inner energy level / second energy level *[1]*
that is closer to the nucleus / more strongly attracted. *[1]*

SL B .99w

6. (a) Chlorine is non polar/exists as discrete small molecules. *[1]*
The forces of attraction between chlorine molecules are weak van de Waals forces. *[1]*
Sodium is a metal and there is metallic bonding between sodium atoms. *[1]*
Silicon has a network covalent/macromolecular/giant covalent structure. *[1]*
Strong covalent bonds hold the silicon atoms together. *[1]*

(b) K has 19 electrons and 19 protons, outer electron is in a higher energy level/further from nucleus. *[1]*
Cl^{-}, Ar and K^{+} all have the same electronic configuration. *[1]*
Cl^{-} has 18 electrons and 17 protons so the outer electrons are not held so strongly. *[1]*
Ar has 18 electrons and 18 protons. *[1]*
K^{+} has 18 electrons and 19 protons so the outer electrons are more strongly attracted to the nucleus. *[1]*

(c) Na_2O reacts with water forming a basic solution, a property typical of a metal oxide. *[2]*
Al_2O_3 can react with either acids or bases (it is amphoteric) *[1]*
a property typical of a metal oxide close to the metal/non metal border. *[1]*
SO_2 forms an acidic solution with water (a property typical of a non metal oxide). *[1]*

accept equations

(d) Na has the electronic configuration 2.8.1. It readily loses one electron from the third level to give a complete outer shell (inert gas configuration). *[1]*
Mg with configuration 2.8.2 has an extra proton which attracts the electrons in the third level more strongly making it harder to remove one electron. *[1]*
It requires more energy to remove an electron from a positive ion than a neutral atom because there is an excess of protons. *[1]*
Na^{+} has the configuration of 2.8 so the second electron is being removed from the second energy level which is closer to the nucleus and more tightly held. *[1]*
Mg^{+} has the configuration 2.8.1 so it is still losing a third level electron to give it an inert gas configuration. *[1]*

SL B .99SQ4

(c) Same group: Na, K *[1 mark]*
Each has $1e^-$/same number of valence e^-s in outer orbital *[1 mark]*

Same period: Na, Cl *[1 mark]*
same number (3) of orbitals containing electrons *[1 mark]*