Paper1 SL

DDCAA ACAAA DACBD

Paper2 SL

2015 May TZ2 Q6

a.i.  ;

Accept any combination of lines, dots or crosses to represent electron pairs.

a.ii *Shape:* tetrahedral;

Bond angle: accept any value in the range: 108° to 111°;

(Literature value is 108.2°).

a.iii Cl is more electronegative than C / C–Cl bond polar;

bond dipoles do not cancel / asymmetric distribution of electron cloud / (resultant) net dipole moment (from vectorial addition of bond dipoles) going in direction of C–Cl axis / *OWTTE*;

a.iv hydrogen bonding in methanol;

stronger than dipole-dipole/van der Waals' attractions/forces in chloromethane;

Accept converse argument.

b.i. $2\mathrm{K(s)} + \mathrm{Cl_2(g)} \rightarrow 2\mathrm{KCl(s)}$;

Ignore state symbols.

b.ii (electrostatic) attraction between lattice of cations/positive ions and delocalized electrons;

b.iii (electrostatic) attraction between positively charged nuclei and a pair of electrons;

formed as a result of electron sharing;

b.iv (electrostatic) attraction between positive and negative ions/oppositely charged ions/cations and anions;

formed as a result of transfer of an electron from a K atom to a Cl atom / *OWTTE*;

2013 May TZ2 Q5

a.i. (electrostatic) attraction between oppositely charged ions/cation and anion/positive and negative ions;

Do not allow electrostatic attraction between metals and non-metals.

a.ii. *Description:*

a lattice is a giant, regular/repeating arrangement/array;

of (chloride) anions/negative ions/Cl^- **and** (sodium) cations/positive ions/Na^+;

each sodium ion surrounded by six chloride ions / each chloride ion surrounded by six sodium ions;

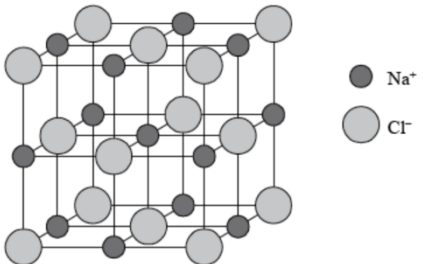
M2 may also be scored from a diagrammatical key or labels on each ion.

M3 may also be scored by a correctly represented cubic representation showing the six-coordination around either the sodium ion or each chloride ion.

Diagram:

cubic lattice type representation (showing **a minimum of one sub-cube and** alternating Na^+ and Cl^- ions);

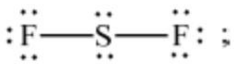
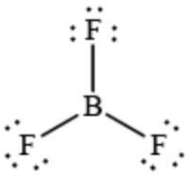
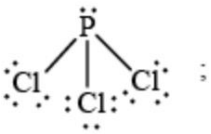
Cl^- shown represented bigger than Na^+ on diagram;



a.iii. $(NH_4)_3PO_4$;

Allow use of square brackets.

b.i.

	SF_2	BF_3	PCl_3
Lewis (electron dot) structure	 ;	 ;	 ;
	Allow any combination of dots/crosses or lines to represent electron pairs. *Penalize missing lone pairs once only.*		
Shape	*v*-shaped/bent/ angular; *Do not allow mark for stating tetrahedral (as this is the electron-domain geometry and not the molecular geometry).* *Penalize tetrahedral once only.*	trigonal/triangular planar; *Do not allow just planar.*	trigonal/triangular pyramidal; *Allow pyramidal (since SL).* *Do not allow mark for stating tetrahedral (as this is the electron-domain geometry and not the molecular geometry).* *Penalize tetrahedral once only.*
	Do not allow ECF from Lewis structures with an incorrect number of negative charge centres.		

b.ii allow any bond angle in the range 97° to less than 109.5° (experimental value is 98°);

due to four negative charge centres/four electron pairs/four electron domains (two of which are lone pairs)/tetrahedral arrangement of electron pairs;

extra repulsion due to two lone pairs of electrons repelling each other / lone pairs occupy more space (than bonding pairs) so F–S–F bond angle decreases from 109.5° / *OWTTE;*

Answers which refer to electronegativity consideration of F's also are correct, as long as LP/LP repulsion is also mentioned to score M3.

b.iii SF_2:

polar because net dipole moment present in molecule / SF bond polarities do not cancel each other out / unsymmetrical distribution of charge / *OWTTE*;

BF_3:

non-polar because no net dipole moment present in molecule / BF bond polarities do cancel each other out / symmetrical distribution of charge / *OWTTE*;

PCl_3:

polar because net dipole moment present in molecule / PCl bond polarities do not cancel each other out / unsymmetrical distribution of charge / *OWTTE*;

*Award **[1 max]** for SF_2 polar, BF_3 non-polar, PCl_3 polar even if explanations are incorrect or are not given.*

Polarity may also be explained using diagrams showing net dipole moments.

c. *IBr:*

$\Delta\chi = (3.0 - 2.7) = 0.3$, covalent

$BaCl_2$:

$\Delta\chi = (3.2 - 0.9) = 2.3$, ionic

CsI:

$\Delta\chi = (2.7 - 0.8) = 1.9$, ionic

HBr:

$\Delta\chi = (3.0 - 2.2) = 0.8$, covalent

2010 Nov Q3

(a) (i) ions/particles accelerated by electric field;
ions/particles deflected by magnetic field; ***[2]***
*Award **[1 max]** for acceleration and deflection of ions without reference to fields.*

(ii) prevents collisions / avoid false readings due to presence of other particles; ***[1]***

(b) $\frac{(54 \times 5.95) + (56 \times 91.88) + (57 \times 2.17)}{100}$;
55.90; ***[2]***
*Award **[2]** for correct final answer.*
Answer must be to 2 d.p.

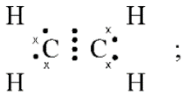
(c) 24; ***[1]***

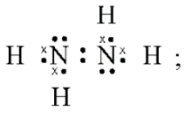
(d) metallic (bonding);
positive ions/cations **and** delocalized/sea of electrons;
electrostatic attraction between the two;
*Award **[2 max]** for description of bonding*

Conductivity:
electrons delocalised/free to move;

Malleability:
atoms/ions/cations can move without breaking bonds / atoms/ions/cations can slide past each other; ***[4]***

2010 Nov Q4

(a) (i)  ;

 ;

[2]

Accept x's, dots or lines for electron pairs.

(ii) *H–C–H:*

any angle between 118° and 122°;
due to three negative charge centres/electron domains/electron pairs;

H–N–H:

any angle between 104° and 108°;
due to four negative charge centres/electron domains/electron pairs;
extra repulsion due to lone electron pairs; ***[5]***

Do not allow ECF for wrong Lewis structures.

(b) (i) (relative) measure of an atoms attraction for electrons;
in a covalent bond / shared pair; ***[2]***

(ii) C–H is less polar as C is less electronegative / N–H bond is more polar as N is more electronegative / difference in electronegativity is greater for N-H than C-H; ***[1]***

(iii) bond polarities cancel in C_2H_4 / *OWTTE*; ***[1]***

(c) weaker van der Waals'/London/dispersion/intermolecular forces in ethene;
stronger (intermolecular) hydrogen bonding in hydrazine; ***[2]***

If no comparison between strengths then ***[1 max]***.

2011 May TZ1 Q7

b. C: 2 **and** Si: 3;

c. *Award* ***[2 max]*** *for three of the following features:*

Bonding

Graphite ***and*** C_{60} *fullerene:* covalent bonds **and** van der Waals'/London/dispersion forces;

Diamond: covalent bonds (and van der Waals'/London/dispersion forces);

Delocalized electrons

Graphite ***and*** C_{60} *fullerene:* delocalized electrons;

Diamond: no delocalized electrons;

Structure

Diamond: network/giant structure / macromolecular / three-dimensional structure **and** *Graphite:* layered structure / two-dimensional structure / planar;

C_{60} *fullerene:* consists of molecules / spheres made of atoms arranged in hexagons/pentagons;

Bond angles

Graphite: 120° **and** *Diamond:* 109°;

C60 fullerene: bond angles between 109–120°;

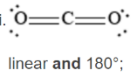
Allow Graphite: sp^2 ***and*** *Diamond:* sp^3.

Allow C_{60} *fullerene:* sp^2 ***and*** sp^3.

Number of atoms each carbon is bonded to

Graphite ***and*** C_{60} *fullerene:* each C atom attached to 3 others;

Diamond: each C atom attached to 4 atoms / tetrahedral arrangement of C (atoms);

d.i. 

linear **and** 180°;

d.ii. network/giant structure / macromolecular;

each Si atom bonded covalently to 4 oxygen atoms **and** each O atom bonded covalently to 2 Si atoms / single covalent bonds;

*Award **[1 max]** for answers such as network-covalent, giant-covalent or macromolecular-covalent.*

Both M1 and M2 can be scored by a suitable diagram.

d.iii *Silicon dioxide:* strong/covalent bonds in network/giant structure/macromolecule;

Carbon dioxide: weak/van der Waals'/dispersion/London forces between molecules;

e. triple (covalent) bond;

one electron pair donated by oxygen to carbon atom / dative (covalent)/coordinate (covalent) bond;

*Award **[1 max]** for representation of* C≡O.

*Award **[2]** if CO shown with dative covalent bond.*

f. $2809 = 3.10 \times 30 + 28x + 29(96.9 - x)$;

$\%\ ^{28}\text{Si} = (93 + 2810.1 - 2809) = 94.1\%$;

*Award **[2]** for correct final answer.*

2012 May TZ2 Q5

a. (i) *Empirical formula:*

simplest (whole number) ratio of atoms/moles of each element present in a compound/molecule;

Molecular formula:

actual numbers of atoms/moles of each element present in a compound/molecule / whole number multiple of empirical formula;

(ii) $n(\text{C}) = 4.54\ (\text{mol}), n(\text{H}) = 9.11\ (\text{mol})$ **and** $n(\text{O}) = 2.27\ (\text{mol})$;

$\text{C}_2\text{H}_4\text{O}$;

Accept other valid method for calculation.

(iii) $\text{C}_4\text{H}_8\text{O}_2$;

(iv) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$;

Accept full or condensed structural formulas.

(v) $\text{CH}_3\text{CH}_2\text{COOCH}_3/\text{CH}_3\text{COOCH}_2\text{CH}_3/\text{HCOOCH}_2\text{CH}_2\text{CH}_3/\text{HCOOCH}(\text{CH}_3)_2$;

Accept full or condensed structural formulas.

(vi) *Stronger bond:*

C=O/double bond;

Longer bond:

C–O/single bond;

b. (i) methoxyethane/ $\text{CH}_3\text{OCH}_2\text{CH}_3$ as there are only dipole-dipole forces (and van der Waals' forces) between molecules;

propan-1-ol has hydrogen bonding between molecules;

hydrogen bonding is stronger than dipole-dipole forces;

(ii) propan-1-ol/ $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ as it has a smaller hydrocarbon chain;

the longer (non-polar) carbon chain in hexan-1-ol decreases the attraction between the alcohol and the (polar) water molecules / *OWTTE*;

c. *graphite*:

forms flat hexagonal rings / layers of carbon atoms each (covalently) bonded to 3 other carbon atoms / trigonal planar around C / C has sp^2 hybridization;

layers are held together by weak intermolecular/van der Waals' forces;

layers can slide over each other;

delocalization of electrons / free moving electrons;

diamond:

all carbon atoms are (covalently) bonded to 4 other carbon atoms / tetrahedral around C / C has sp^3 hybridization;

strong covalent bonds;

no delocalized electrons / *OWTTE*;

2012 Nov Q4

a. (i) *Atomic number*:

number of protons (in nucleus/atom);

Mass number:

(sum of) number of protons **and** neutrons (in nucleus/atom);

Isotopes of an element:

atoms of same element / atoms with same number of protons/atomic number/Z but different number of neutrons/mass number/*A*;

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

*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 maingroup elements) **and** period gives same number of shells/energy levels.*

(iii) Li^+: $2/1s^2$;

B: $2,3/1s^2 2s^2 2p^1$;

(iv) correct mathematical expression set-up (e.g. $\left(\frac{x}{100}\right)(10) + \left[\frac{(100-x)}{(100)}\right](11) = 10.81$);

19%;

*Award **[2]** for correct final answer.*

(v)

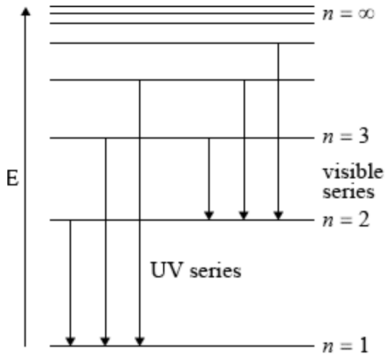
Mass number (*A*)	Number of protons	Number of electrons	Number of neutrons
6	3	3	3
7	3	3	4

b. (i) *Continuous spectrum:* radiation spread over all wavelengths/frequencies/energies/colours / *OWTTE*;

Line spectrum: radiation (absorbed/emitted) at certain/specific wavelengths/frequencies/energies/colours / *OWTTE*;

Allow series of (separate/discrete) lines which converge/get closer together at high energy / OWTTE.

(ii)



showing *y*-axis labelled as energy/E **or** labelling at least two energy levels

($n = 1$, $n = 2$ *etc.* but not for $n = 0$);

showing energy levels converging;

showing jumps to $n = 1$ for ultraviolet series;

showing jumps to $n = 2$ for visible series;

UV and visible must be labelled.

c. (i) metals have delocalized electrons / sea of electrons which are mobile/can move / *OWTTE*;

layers/positive ions/cations/atoms slide past/over each other / *OWTTE*;

Do not accept nuclei for M2.

(ii) Fe^{2+} **and** Fe^{3+} ;

(iii) *Lithium oxide*: Li_2O **and** *Iron(II) oxide*: FeO;

2013 Nov Q4

a. $\underline{(1)}\ \mathrm{N(NO_2)_3(g)} + \underline{2}\ \mathrm{CH_3OH(l)} \rightarrow \underline{2}\ \mathrm{N_2(g)} + \underline{2}\ \mathrm{CO_2(g)} + \underline{4}\ \mathrm{H_2O(l)}$;

c. *bonds broken:* $(6 \times 305) + (3 \times 158) = 1830 + 474 = 2304\ (\mathrm{kJ\,mol^{-1}})$;

bonds made: $(2 \times 945) + (3 \times 498) = 1890 + 1494 = 3384\ (\mathrm{kJ\,mol^{-1}})$;

enthalpy change: $2304 - 3384 = -1080\ (\mathrm{kJ\,mol^{-1}})$;

*Award **[3]** for correct final answer.*

*Award **[2 max]** for +1080 (kJ mol^{-1}) .*

Accept –234 kJ mol^{-1} which arise from students assuming that 305 kJ mol^{-1} refers to the strength of a single N–O bond. Students may then take N=O from the data book value (587 kJ mol^{-1}).

bonds broken: (3 × 305) + (3 × 587) + (3 × 158) = 915 + 1761 + 474 = 3150 (kJ mol^{-1})

bonds made: (2 × 945) + (3 × 498) = 1890 + 1494 = 3384 (kJ mol^{-1})

enthalpy change: 3150 – 3384 = –234 (kJ mol^{-1}) .

*Award **[2 max]** for correct calculation of the enthalpy change of reaction for the equation in part (a), which gives –2160 (kJ mol^{-1}).*

*Award **[1]** if the final answer is not –2160 but the candidate has correctly calculated the bonds broken in trinitramide as 2304 (kJ mol^{-1}).*

d. (N–N bond in) trinitramide is longer/nitrogen (gas) is shorter / 0.145 nm in trinitramide versus 0.110 nm in nitrogen;

trinitramide has single (N–N) bond **and** nitrogen (gas) has triple bond;

e. 106°–108°;

Accept $<109°$.

*Any two for **[2 max]**.*

4 (negative) charge centres/electron pairs/electron domains around central nitrogen;

central nitrogen has a lone/non-bonding pair;

lone/non-bonding pairs repel more than bonding pairs;

molecule will be (trigonal/triangular) pyramidal;

(negative) charge centres/electron pairs/electron domains will be tetrahedrally arranged/orientated/ have tetrahedral geometry;

Do not apply ECF.

f. polar;

net dipole moment present in molecule / unsymmetrical distribution of charge / polar bonds do not cancel out / centre of negatively charged oxygen atoms does not coincide with positively charged nitrogen atom;

g.i. burn/combust a (known) mass/volume/quantity/amount of methanol (in a spirit burner) / weigh methanol/spirit burner before and after combustion;

use flame to heat a (known) mass/volume/quantity/amount of water;

measure the increase/rise/change in temperature (of the water);

g.ii. calculate the heat gained by the water / calculate the heat evolved by the burning methanol / substitute in $q = mc\Delta T$;

calculate the amount/moles of methanol / divide the mass of methanol by its molar mass;

divide the heat gained by the water by the amount/moles of methanol;

g.iii. result would be less exothermic/less negative;

Accept "less/smaller/lower".

heat loss / incomplete combustion;