1. Sc has no d electrons as an ion / Cu has d electrons;
Cu compounds are coloured / Sc compounds are colourless;
Cu has more than one oxidation state / Sc has only one oxidation state;
Cu compounds can act as catalysts / Sc cannot act as catalysts; 3 max

[3]

;**2.** (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

[4]

Cu compounds can act as catalysts / Sc cannot act as catalysts; 3 max

[3]

3. A

[1]

4. *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

[4]

5. (a) as (cat)ion becomes more positive / Na^+, Mg^{2+}, Al^{3+} / size/radius decreases / charge density increases;
Do not allow increasing number of protons or increasing nuclear charge.

attraction for mobile/valence/delocalized/sea of electrons increases;
Do not accept "cloud of electrons". 2

(b) larger molecule / higher M_r/ M / greater number of electrons;
Do not accept "larger/higher/greater mass".

greater van der Waals'/dispersion/London forces; 2

(c) *Si*: giant/network/macromolecular/3-D covalent bonding;
No mark for strong bonding without reference to covalent and network.
No mark for molecular.

Ar: (simple) atomic / (only weak) van der Waals'/dispersion/London forces;
No mark for (simple) molecular. 2

[6]

6. (i) atomic number / Z;
Accept nuclear charge / number of protons. 1

(ii) *Across period 3:*
increasing number of protons / atomic number / Z / nuclear charge;
(atomic) radius/size decreases / same shell/energy level / similar shielding/screening (from inner electrons);
No mark for shielding/screening or shielding/screening increases.

Noble gases:
do not form bonds (easily) / have a full/stable octet/shell/energy level / cannot attract more electrons;
Do not accept "inert" or "unreactive" without reference to limited ability/ inability to form bonds or attract electrons. 3

[4]

7. (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;
Allow converse for Na.
Do not accept larger nucleus. 1

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

(v) the radii of the metal atoms increase (from Li → 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

[10]

8. A

[1]

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

Carbon dioxide: weak/van der Waals'/dispersion/London forces between molecules; 2

[2]

10. triple (covalent) bond;
one electron pair donated by oxygen to carbon atom / dative (covalent)/ coordinate (covalent) bond; 2
*Award **[1 max]** for representation of C≡O.*
*Award **[2]** if CO shown with dative covalent bond.*

[2]

$\rightarrow M^+ (g) + e^-$/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;
Allow converse for Na.
Do not accept larger nucleus. 1

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

(v) the radii of the metal atoms increase (from Li → 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

[10]

11. A

[1]

12. D

[1]

13. D

[1]

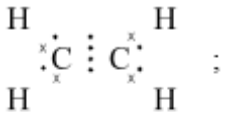
14. A

[1]

15. B

[1]

16. (a) (i)



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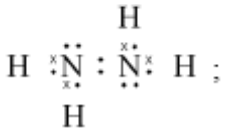


;

Accept ×'s, dots or lines for electron pairs. 2

(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;
Do not allow ECF for wrong Lewis structures. 5

(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;
If no comparison between strengths then ***[1 max]***. 2

[13]

17. A

[1]

18. boiling points increase going down the group (from PH_3 to AsH_3 to SbH_3);
M_r/number of electrons/molecular size increases down the group;
Accept electron cloud increases down the group for the second marking point.

greater dispersion/London/van der Waals' forces;

NH_3/ammonia has a higher boiling point than expected due to the hydrogen bonding between the molecules;
Do not accept hydrogen bonding alone. 4

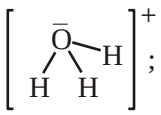
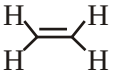
[4]

19. (i) Find number of electron pairs/charge centres in (valence shell of) central atom;
electron pairs/charge centres (in valence shell) of central atom repel each other;

Any one of the following:
to positions of minimum energy/repulsion / maximum stability;
pairs forming a double or triple bond act as a single bond;
non-bonding pairs repel more than bonding pairs / *OWTTE*; 3 max

Do not accept repulsion between bonds or atoms.

(ii) 6

Species	Lewis (electron-dot) structure	Shape	Bond angle(s)
H_3O^+	 ;	Trigonal/triangular pyramidal;	Allow values in the range 106° to 109.5°;
C_2H_4	 ;	Trigonal/triangular planar;	Allow values of approximately 120°;

Accept crosses and dots for electrons in Lewis structures also.
As the Lewis structures were asked for, and not 3D representations, do not penalize incorrectly drawn geometries.
Do not accept structure of hydronium cation without lone pair on oxygen.
No penalty for missing charge.

(iii) H_3O^+: is polar and explanation either using a diagram or in words, involving the net dipole moment;

e.g. the three individual O-H bond dipole moments add as vectors to give a net dipole moment.

C_2H_4: is non-polar and explanation either using a diagram or in words, involving no net dipole moment; 2

e.g. the vector sum of the individual bond dipole moments is zero.

*For simple answers such as bond polarities do not cancel for H_3O^+ and do cancel for C_2H_4, Award **[1]**, only for the last two marking points.*

(iv) O-H is most polar;
O-H has greatest difference between electronegativities / calculation showing values of 1.4, 0.5 and 0.9 respectively; 2

[13]