IB Chemistry – SL

Topic 3 Answers

1. D

[1]

2. B

[1]

3. C

[1]

4. B

[1]

5. B

[1]

6. C

[1]

7. B

[1]

8. C

[1]

9. B

[1]

10. A

[1]

11. C

[1]

12. A

[1]

13. C

[1]

14. D

[1]

15. D

[1]

16. D

[1]

17. D

[1]

18. A

[1]

19. B

[1]

20. D

[1]

21. C

[1]

22. C

[1]

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

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

[4]

24. *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 Waals' forces between molecules;
as size increases van der Waals' 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".

P → Ar:
simple molecular (atomic in case of Ar) substances with weak van der Waals' forces (and lower melting points);
trend in P_4, S_8, Cl_2, Ar due to size/mass of particles; 8
Award mark for "decreasing mass or size".
Molecular formulae not necessary.

[8]

25. *(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

[8]

26. (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

[4]

27. (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).*

[5]

28. (i) *Li to Cs*
atomic radius increases;
because more full energy levels are <u>used</u> or <u>occupied</u>/<u>outer</u> 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 <u>increased</u> 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.

[8]

29. (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

[7]

30. (a) (i) *aluminium oxide*
amphoteric;

(ii) *sodium oxide*
basic;

(iii) *sulfur dioxide*
acidic; 3

(b) (i) $Na_2O + H_2O \rightarrow 2Na^+ + 2OH^-$;

(ii) $SO_2 + H_2O \rightarrow H_2SO_3$; 2
Accept NaOH and $H^+ + HSO_3^-$/$2H^+ + SO_3^{2-}$.

[5]

31. (a) sulfur is (simple) molecular;
(contains) covalent bonds/no delocalized electrons/all (outer) electrons used in bonding;
aluminium contains positive ions and delocalized electrons;
(delocalized) electrons move (when voltage applied or current flows); 4

(b) silicon dioxide is macromolecular/giant covalent;
many/strong covalent bonds must be broken; 2

*Award max **[1]** if no mention of covalent.*

Do not accept weakened instead of broken.

[6]

32. (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

[5]

33. 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.

[5]

34. (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

[5]

35. (a) (i) the ability of an atom to attract a <u>bonding</u> pair of electrons;
inert/do not react/do not attract electrons/stable electron configuration/full outer electron shell/do not form bonds; 2

(ii) electronegativity increases (along period 3 from Na to Cl);
number of protons increases/nuclear charge increase/core charge increase/size of atom decreases; 2

Do not accept "greater nuclear attraction".

(iii) Cl_2 stronger oxidising agent;

Cl_2 has greater attraction for electrons/has a higher electron affinity; 2

Accept converse statements for Br_2.

(b) MgO – basic oxide/alkali;
$MgO + 2HCl \rightarrow MgCl_2 + H_2O$/$MgO + H_2O \rightarrow Mg(OH)_2$;

Al_2O_3 – amphoteric oxide/acidic and basic oxide;
$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$;
$Al_2O_3 + 2OH^- + 3H_2O \rightarrow 2Al(OH)_4^-$/$Al_2O_3 + 2OH^- \rightarrow 2AlO_2^- + H_2O$;

P_4O_6 – acidic oxide;
$P_4O_6 + 6H_2O \rightarrow 4H_3PO_3$; 7

All equations must be balanced.

[13]

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

(ii) $2Li(s) + 2H_2O(1) \rightarrow 2LiOH(aq) + H_2(g)$/$Li(s) + H_2O(1) \rightarrow LiOH(aq) + 1/2H_2(g)$; 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

(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

[11]

37. $IE_S < IE_O$:

valence electron in S in n = 3, in O in n = 2/e^- further away/S has another electron shell/atomic radius of S greater than that of O;
less attracted to nucleus/experiences greater screening from inner electrons;
$IE_S < IE_P$:

electron removed from S is paired;

greater repulsion due to two electrons in the same (p) orbital/paired electrons in S; 4

[4]

38. (i) Mg has greater nuclear charge/greater charge on cation/more valence e^-/greater number of delocalized electrons/Na has lesser nuclear charge/lesser charge on cation/less valence e^-/lesser number of delocalized electrons; stronger attraction between cation and delocalized/free/valence electrons; 2

*If neither mark scored, accept stronger metallic bonding in Mg for **[1 max]**.*

(ii) giant/network/lattice/macromolecular structure;
many/strong covalent bonds (need to be broken); 2

(iii) (simple) molecular substances;
weak van der Waals'/dispersion/London forces between molecules; 2
"Weak intermolecular forces" not sufficient for second mark

[6]

39. Oxides of: Na and Mg are basic;
Al is amphoteric;
Si to Cl are acidic;
Ar has no oxide;
*All four correct award **[2]**, two or three correct award **[1]**.*

$Na_2O + H_2O \rightarrow 2NaOH$ **and** $SO_3 + H_2O \rightarrow H_2SO_4$; 3
Must be balanced for mark.
Award marks for alternative correct equations such as SO_3 with NaOH.

[3]

40. (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

[5]

41. (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
*Award **[1]** each for any two of last three observations.*

[8]

42. (a) the ability of an element/atom/nucleus to attract a <u>bonding</u> 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.

[5]