M1.(a) $5s^2\ 4d^{10}\ 5p^4$ / $4d^{10}\ 5s^2\ 5p^4$

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^4$
or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^4$
Allow any order but must finish with $5p^4$

1

(b) (i) $\frac{(124\times2)+(126\times4)+(128\times7)+(130\times6)}{19}$ or $\frac{2428}{19}$

M1 for top line

1

$\frac{127.8}{}$

M2 for correct denominator

1

127.8 with no working shown scores 3 marks

1

Or

$$\frac{(124\times10.5)+(126\times21.1)+(128\times36.8)+(130\times31.6)}{100}$$

1

Mark for 100 dependent on top line correct

1

$\frac{127.8}{}$

1

(ii) Other <u>isotopes</u> present / some <u>isotopes</u> absent / different abundances of <u>isotopes</u>

1

(c) $Te^+ + e^{(-)} \rightarrow Te$

Ignore state symbols
Allow $Te^{2+} + 2e^{(-)} \rightarrow Te$

1

(d) 128

Only

1

Most abundant ion (QoL − superlative)

M2 dependent on correct M1

1

(e) 2+ ion formed / 2 electrons removed

Due to $^{128}Te^{2+}$ = 2 marks

1

From ^{128} (Te)

Mark independently

1

(f) Same

If not same CE = 0 / 2

1

(Each isotope has the) same number of protons / same nuclear charge and same number of electrons / electronic configuration

Ignore more neutrons in ^{130}Te

1

[12]

M2.(a) Silicon / Si

If not silicon then CE = 0 / 3

1

covalent (bonds)

M3 dependent on correct M2

1

Strong or many of the (covalent) bonds need to be broken / needs a lot of energy to break the (covalent) bonds

Ignore hard to break

1

(b) Argon / Ar

If not argon then CE = 0 / 3. But if Kr chosen, lose M1 and allow M2+M3

1

Large(st) number of protons / large(st) nuclear charge

Ignore smallest atomic radius

1

Same amount of shielding / same number of shells / same number of energy levels

Allow similar shielding

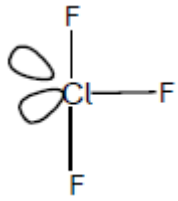
1

(c) Chlorine / Cl

*Not Cl_2, Not C**L**, Not Cl^2*

1

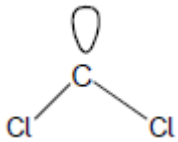
(d) (i)



Or any structure with 3 bonds and 2 lone pairs

Ignore any angles shown

1



Or a structure with 2 bonds and 1 lone pair

1

(ii) Bent / v shape

Ignore non-linear, angular and triangular

Apply list principle

1

(iii) $\frac{1}{2}Cl_2 + \frac{3}{2}F_2 \longrightarrow ClF_3$

No multiples

Ignore state symbols

1

[11]

M3.(a) 0.943 g water (M1)

If Mr of $NiSO_4$ wrong, can allow M1 and M3 from method 1 i.e. max 2

$NiSO_4$	H_2O
$\frac{1.344}{154.8}$ (M2)	$\frac{0.943}{18}$ (M3)
(8.68×10^{-3}	0.052)
1	6 or $x = \underline{6}$ (M4)

Allow Mr = 155

Allow other methods e.g.

M_r ($NiSO_4$) = 58.7 + 32.1 + 64.0 = 154.8

n($NiSO_4$) = $\frac{1.344}{154.8}$ = 0.008682 mol (M1)

M_r ($NiSO_4.xH_2O$) = $\frac{2.287}{0.008682}$ = (263.4) (M2)

so $18x$ = 263.4 − 154.8 = (108.6) (M3)

so x = $\frac{108.6}{18}$ = 6 (M4)

If using alternative method and Mr of $NiSO_4$ wrong, allow ecf to score M2 and M3 only i.e. max 2

4

(b) re-heat

Heat to constant mass = 2 marks

1

check that mass is unchanged

M2 dependent on M1

Allow as alternative:

M1: record an IR spectrum

M2: peak between 3230 and 3550 (cm^{-1})

1

[6]

M4.(a) M1 550 × $\frac{100}{95}$ = 579 g would be 100% mass

Allow alternative methods.

There are 4 process marks:

1

M2 So $\frac{579}{65}$ = 8.91 moles NaN_3

or

M1 $\frac{550}{65}$ = 8.46 moles NaN_3 (this is 95%)

M2 So 100% would be $8.46 \times \frac{100}{95}$ = 8.91 moles NaN_3

1: mass ÷ 65

2: mass or moles × 100 / 95 or × 1.05

3: moles NaN_3 × 2

4: moles $NaNH_2$ × 39

1

Then M3 Moles $NaNH_2$ = 8.91 × 2 = (17.8(2) moles)

1

M4 mass $NaNH_2$ = 17.8(2) × 39

1

M5 693 or 694 or 695 (g)

If 693, 694 or 695 seen to 3 sig figs award 5 marks

1

(b) M1 308 K and 150 000 Pa

1

M2 $n = \frac{PV}{RT}$ or $\frac{150\ 000 \times 7.5 \times 10^{-2}}{8.31 \times 308}$

1

M3 = 4.4(0) or 4.395 moles N_2

Allow only this answer but allow to more than 3 sig figs

1

M4 Moles NaN_3 = 4.395 × $\frac{2}{3}$ (= 2.93)

M4 is for M3 × $\frac{2}{3}$

1

M5 Mass NaN_3 = (2.93) × 65

M5 is for moles M4 × 65

1

M6 = 191 g

Allow 190 to 191 g allow answers to 2 sig figs or more

1

(c) (i) 150 / 65 = 2.31 moles NaN_3 or 2.31 moles nitrous acid

1

Conc = $2.31 \times \frac{1000}{500}$

M2 is for M1 × 1000 / 500

1

4.6(1) or 4.6(2) (mol dm^{-3})

Only this answer

1

(ii) $3HNO_2 \longrightarrow HNO_3 + 2NO + H_2O$

Can allow multiples

1

(d) Ionic

If not ionic then CE = 0 / 3

1

Oppositely charged ions / Na^+ and N_3^- ions

Penalise incorrect ions here but can allow M3

1

Strong attraction between (oppositely charged) ions / lots of energy needed to overcome (strong) attractions (between ions)

M3 dependent on M2

1

(e) (i) $N \equiv N \longrightarrow N^-$

Only

1

(ii) CO_2 / N_2O / BeF_2 / HN_3

Allow other correct molecules

1

(iii) MgN_6

Only

1

[21]

M5.(a) 94−105.5°

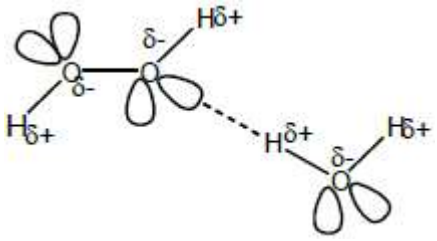
1

(b) (i) Hydrogen bond(ing) / H bonding / H bonds

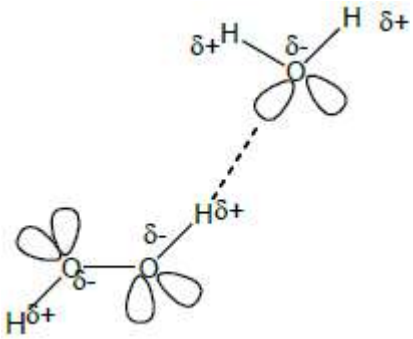
Not just hydrogen

1

(ii)



OR



1 mark for all lone pairs

1 mark for partial charges on the O and the H that are involved in H bonding

1 mark for the H-bond, from Hδ+ on one molecule to lone pair on O of other molecule

3

(c) Electronegativity of S lower than O or electronegativity difference between H and S is lower

Mark independently

1

No hydrogen bonding <u>between H_2S_2 molecules</u>

Or <u>only</u> van der Waals / <u>only</u> dipole-dipole forces <u>between H_2S_2 molecules</u>

If breaking covalent bonds CE = 0

1

[7]

M6.(a) (i) M1 - M_r calcium phosphate = 310(.3)

If M_r wrong, lose M1 and M5.

1

M2 - Moles calcium phosphate = $\frac{7.26}{M1}$ (= 0.0234)

0.0234 moles can score M1 and M2.

If M_r incorrect, can score M2 for $\frac{7.26}{M1}$.

Allow M2 and / or M3 to 2 significant figures here but will lose M5 if answer not 1.23.

1

M3 - Moles phosphoric acid = 2 × 0.0234 = 0.0468

Allow student's M2 × 2. If not multiplied by 2 then lose M3 and M5.

1

M4 - Vol phosphoric acid = 0.038(0) dm^3

If not 0.038(0) dm^3 then lose M4 and M5.

1

Conc phosphoric acid = $\frac{0.0468}{0.038(0)}$

M5 = 1.23 (mol dm^{-3})

This answer only – unless arithmetic or transcription error that has been penalised by 1 mark.

Allow no units but incorrect units loses M5.

1

(ii) $\frac{492.3}{688.3} \times 100$ **OR** $\frac{492}{688} \times 100$

1 mark for both M_r correctly placed.

= 71.5%

2

(b) $3Ca(OH)_2 + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 6H_2O$

Allow multiples.

1

(c)

Ca	H	P	O
1.67 / 40.1	0.17 / 1	2.59 / 31	5.33 / 16
= 0.042 / 1	0.17 / 4	0.084 / 2	0.333 / 8

If x = 2 with no working, allow M4 only.
Ca = 1.67 g (M1).

1

Mark for dividing by correct A_r in Ca and P (M2).
If M1 incorrect can only score M2.

1

Correct ratio (M3).

1

$CaH_4P_2O_8$ **OR** $Ca(H_2PO_4)_2$ **OR** x = 2
Value of x or correct formula (M4).

1

Alternative

Ca H_2PO_4
Ca = 1.67 g (M1).

$\frac{1.67}{40.1}$ $\frac{8.09}{97.0}$

Mark for dividing by correct A_r / M_r in Ca and H_2PO_4 (M2).
If M1 incorrect can only score M2.

$= \frac{0.042}{1}$ $\frac{0.083}{2}$

Correct ratio (M3).

$CaH_4P_2O_8$ **OR** $Ca(H_2PO_4)_2$ **OR** x = 2
Value of x or correct formula (M4).

[12]

M7.D

[1]

M8.D

[1]

M9.C

[1]

M10.B

[1]

M11.A

[1]

M12.D

[1]

M13.B

[1]

M14.B

[1]

M15.C

[1]

M16.A

[1]

M17.B

[1]