1. (a) (i) Calculate correctly $\dfrac{0.0880 \times 25.0}{1000} = 2.20 \times 10^{-3}$ mol

OR 0.00220 mol ✓

ALLOW *0.0022* ***OR*** *2.2 × 10^{-3} mol*

1

(ii) Calculates correctly $\dfrac{0.00220}{2} = 1.10 \times 10^{-3}$ mol

OR 0.00110 mol ✓

ALLOW *0.0011* ***OR*** *1.1 × 10^{-3} mol*

ALLOW *ECF for answer* ***(i)****/2 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes*

1

(iii) $\dfrac{0.00110 \times 1000}{17.60} = 0.0625 \text{ mol dm}^{-3}$

OR 6.25 × 10^{-2} mol dm^{-3} ✓

ALLOW *0.063* ***OR*** *6.3 × 10^{-2} mol dm^{-3}*

ALLOW *ECF for answer* ***(ii)*** *× 1000/17.60*

OR

ECF from ***(i)*** *for answer* ***(i)****/2 × 1000/17.60 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes*

1

(b) (i) (The number of) Water(s) of crystallisation ✓

IGNORE *hydrated* ***OR*** *hydrous*

1

(ii) 142.1 ✓

ALLOW *142*

ALLOW *M_r expressed as a sum*

ALLOW *ECF from incorrect M_r and x is* ***calculated correctly***

$x = \dfrac{(322.1 - 142.1)}{18.0} = 10$ ✓

ALLOW *ECF values of x from nearest whole number to calculator value*

ALLOW *2 marks if final answer is 10* ***without any working***

2

[6]

2. (i) O goes from –2 to 0 ✓

Oxidation numbers may be seen with equation

N goes from +5 to +4 ✓

N is reduced **AND** O is oxidised ✓

Third mark is dependent upon seeing a reduction in oxidation number of N and an increase in oxidation number of O

ALLOW *ECF for third mark for N is oxidised* ***and*** *O is reduced if incorrect oxidation numbers support this*

IGNORE *references to strontium*
IGNORE *references to electron loss* ***OR*** *gain*

DO NOT ALLOW *'One increases and one decreases'*

3

(ii) Calculates correctly:

Mol of $Sr(NO_3)_2 = \dfrac{5.29}{211.6} = 0.0250$ ✓

ALLOW *0.025*

Calculates correctly:
Mol of gas = 5/2 × 0.0250 = 0.0625 ✓

ALLOW *ECF for first answer × 2.5 as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes*

Calculates correctly:
Volume of gas = 24.0 × 0.0625 = 1.50 dm^3 ✓

ALLOW *ECF for second answer × 24(.0) as calculator value or correct rounding to 2 significant figures or more but ignore trailing zeroes*

DO NOT ALLOW *ECF of first answer × 24(.0) (which gives 0.6(0) dm^3) as this has not measured the volume of any gas, simply 0.0250 mol of solid $Sr(NO_3)_2$ converted into a gas*

i.e. This answer would give ***one*** *mark*

ALLOW *1.5 dm^3*

ALLOW *ECF producing correct volume of NO_2 only*

i.e. 1.2(0) dm^3 would give ***two*** *marks*

OR

ALLOW *ECF producing correct volume of O_2 only*

i.e. 0.3(0) dm^3 would give ***two*** *marks*

3

[6]

3. (i) 0.0268 **OR** 0.027 **OR** 0.02675 mol ✓

NO OTHER ACCEPTABLE ANSWER

1

(ii) 1.61×10^{22}✓

ALLOW *1.6×10^{22} up to calculator value*

ALLOW

ECF *answer to* ***(i)*** *$\times 6.02 \times 10^{23}$*

ALLOW *any value for N_A in the range:*

$6.0 \times 10^{23} - 6.1 \times 10^{23}$

1

[2]

4. (a) BaO ✓

Ba_3N_2 ✓

Treat any shown charges as working and ignore.

Treat B for Ba as a slip

2

(b) (i) $\frac{0.11}{137.3}$ ✓

mark is for the ***working out*** *which* ***MUST*** *lead to the correct answer of 8×10^{-4} up to calculator value*

1

(ii) 19.2

OR

calculated answer to **(b)(i)** × 24000 ✓

ALLOW *19 up to calculator value.*

1

(iii) 8.0×10^{-3}

OR

calculated answer to **(b)(i)** × 10 ✓

ALLOW *8.01×10^{-3} up to calculator value*

1

(iv) any pH > 7 but <15 ✓

ALLOW *a correct range of pH.*

1

(c) Less barium to react **OR**

some barium has already reacted ✓

ALLOW less volume because contains some BaO or Ba_3N_2

1

(d) reactivity increases (down the group) ✓

atomic radii increase **OR**
there are more shells ✓

there is **more** shielding **OR more** screening ✓

the nuclear attraction decreases **OR**
Increased shielding and distance outweigh the increased nuclear charge ✓

easier to remove (outer) electrons **OR**
ionisation energy decreases ✓

USE annotations with ticks, crosses, ecf, etc for this part.

***DO NOT ALLOW** more orbitals **OR** more sub-shells*

*'**More**' is essential*

***ALLOW** 'more electron repulsion from inner shells'*

***ALLOW** 'nuclear pull'*

***IGNORE** any reference to 'effective nuclear charge'*

***ALLOW** easier to form positive ion*

5

[12]

5. (i) mol HCl = 1.50×10^{-2} ✓

volume HCl(aq) = 75.0 ✓

***ALLOW** answers to 2 significant figures*

***ALLOW** ecf from wrong number of moles*

i.e $\dfrac{\text{moles of HCl} \times 1000}{0.200}$

***ALLOW** one mark for 37.5 (from incorrect 1:1 ratio)*

2

(ii) 180 ✓

No other acceptable answer

1

[3]

6. (i) Molar mass of $CaCO_3$ = 100.1 g mol^{-1} **(1)**
2.68/100.1 = 0.0268/0.027 **(1)** 2

(ii) 0.0268 mol × 24,000 = 643 cm^3 **(1)** 1

(iii) moles HNO_3 = 2 × 0.0268
= 0.0536 /0.054 mol **(1)**
(i.e. answer to (i) × 2)

volume of HNO_3 = 0.0536 × 1000/2.50 = 21.4 cm^3 **(1)** 2

[5]

7. (i) **Simplest (whole number) ratio** of atoms/moles/elements ✓ 1

(ii) ratio Rb : Ag : I = 7.42/85.5 : 37.48/108 : 55.10/127
or 0.0868 : 0.347 : 0.434
or 1 : 4 : 5 ✓
= $RbAg_4I_5$ ✓ 2

[3]

8. (a) (i) 12 × 50/1000 = 0.600 mol ✓ 1

(ii) 4 mol HC*l* → 1 mol C*l*$_2$ / moles C*l*$_2$ = 0.15 mol ✓
vol of C*l*$_2$ = 0.15 × 24 = 3.60 dm^3 ✓ 2
2nd mark is consequential on molar ratio given

(b) Evidence that the oxidation number of Mn has reduced
and one of the oxidation numbers correct (ie MnO_2: ox no
of Mn = +4 or MnC*l*$_2$: ox no of Mn = +2 ✓
The **other** oxidation number of Mn is correct,
ie in MnO_2: ox no of Mn = +4
or in MnC*l*$_2$: ox no of Mn = +2 ✓ 2

[5]

9.	(i)	mass = $0.0500 \times 23.0 = 1.15$ g ✓	1
	(ii)	moles $H_2 = 0.0250$ ✓ volume $H_2 = 0.0250 \times 24 = 0.600$ dm^3 ✓ ecf from calculated moles H_2	2
		0.0500 mol in 50.0 cm^3	1
	(iii)	concentration = $0.0500 \times 20 = 1.00$ mol dm^{-3} ✓	

[4]

10.	(i)	$2Na + O_2 \rightarrow Na_2O_2$ ✓	1
	(ii)	$Na_2O_2 + 2H_2O \rightarrow H_2O_2 + 2NaOH$ ✓	1
	(iii)	correct covalent bonds shown ✓ electron count (14) for rest of molecule correct ✓	2

[4]

11. M(BaO) = 137 + 16 = 153 ✓
moles BaO = 500/153 or 3.268 mol ✓
moles Ba = 3.268/2 or 1.634 ✓
mass Ba formed = $1.634 \times 137 = 224$ g ✓

accept 223.856209/223.86/223.9 g.
if 6 mol BaO forms 3 mol Ba, award 3rd mark

Alternative method
mass 6BaO=918 g ✓
mass 3Ba = 411 g ✓
1g BaO forms 411/918 g Ba ✓
500 g BaO forms 223.856209/223.86/223.9 g Ba ✓

[4]

12. (i) ratio N : H : S : O = $\dfrac{24.12}{14} : \dfrac{6.94}{1} : \dfrac{27.61}{32.1} : \dfrac{41.33}{16}$:✓

= 2 : 8 : 1 : 3

Empirical formula = $N_2H_8SO_3$✓
$N_2H_4SO_3$ is worth 1 mark from consistent use of at nos. — 2

(ii) $H_2O + 2NH_3 + SO_2 \rightarrow (NH_4)_2SO_3$✓ — 1
(Award mark for $N_2H_8SO_3$)

[3]

13. (a) (i) Amount of substance that has the same number of particles as there are atoms in 12 g of ^{12}C/ 6×10^{23}/ Avogadro's Number✓ 1

(ii) moles = $\frac{0.275 \times 120}{1000}$ = 0.0330 mol✓

moles Cl_2 = $\frac{0.0330}{2}$ = 0.0165 mol✓ 1

(iii) volume Cl_2 = 0.0165 × 24000 = 396 cm^3 ✓/ 0.396 dm^3

792 cm^3 worth 1 mark (no molar ratio)

1584 cm^3 worth 1 mark (x 2)

units needed. 2

(iv) bleach / disinfectant /sterilising /killing germs✓ 1

(b) $NaClO_3$✓ 1

[6]

14. (i) Mass Sb_2S_3 in stibnite = 5% of 500 kg = 25.0 kg ✓

Moles Sb_2S_3 = $\frac{25.0 \times 10^3}{340}$ / 73.5/ 73.529 /73.53/ 74 mol ✓

(calculator value: 73.52941176)

If 5% is not used, 1471 mol; ecf for 2nd mark

(calculator value: 1470.588235)

If 5% is used 2nd, 73.6 mol: OK for both marks 2

(ii) moles Sb = 2 × 73.5 mol ✓

mass Sb = 2 × 73.5 × 122 g = 17.9 kg ✓

If the 2 isn't used, answer = 73.5 × 122 = 8.95 ✓

ecf ans from (i) x 2

ecf ans above x 2

OR

% Sb = 244/340 = 71.7% ✓

mass Sb = 25.0 × 71.7/100 = 17.9 kg ✓ (ecf as above) 2

[4]

15. (i) Molar mass CaO = 56.1 (g mol^{-1}) ✓ (anywhere) 2

moles CaO = $\frac{1.50}{56.1}$ = = 0.0267/0.027 ✓ calc: 0.0267379

Allow 56 which gives 0.0268

(ii) moles HNO_3 = 2 × 0.0267

= 0.0534 or 0.0535 /0.053 mol ✓

(i.e. answer to (i) x 2)

volume of HNO_3 = $\frac{0.0534\,(\text{or } 5) \times 1000}{2.50}$ = 21.4 cm^3 ✓ 2

calc from value above = 21.3903743

If 0.053 mol, answer is 21 cm^3 but accept 21.2 cm^3
If 0.054 mol, answer is 22 cm^3 but accept 21.6 cm^3

[4]

16. (i) dative covalent, bonded pair comes from same atom/
electron pair is donated from one atom/
both electrons are from the same atom ✓ 1

(ii) $Ca(NO_3)_2$ ✓ $\rightarrow$ $CaO + 2NO_2 + \frac{1}{2}O_2$ ✓
or double equation with 2/2/4/1 1

[2]

17. (i) 203.3 g mol^{-1} ✓ 1
Accept 203

(ii) white precipitate / goes white ✓ 1

(iii) $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
equation ✓
state symbols ✓ 2
$AgCl$ dissolves in $NH_3(aq)$ ✓

(iv) AgBr dissolves in **conc** $NH_3(aq)$/
partially soluble in $NH_3(aq)$ ✓

AgI insoluble in $NH_3(aq)$ ✓ 3

[7]

18. (i) moles CO_2 = 1000 /44 mol = 22.7 mol ✓
volume CO_2 in 2000 = 22.7 × 24 = 545 dm^3 ✓

(ii) reduction = 545 × 60/100 = 327 dm^3 ✓

[3]

19. (i) moles HCl = 2.0 × 50/1000 = 0.10 ✓ 1

(ii) moles Ca = ½ × moles HCl = 0.050 ✓
mass Ca = 40.1 × 0.050 = 2.00 g / 2.005 g ✓ 2
(accept 40 × 0.050 = 2.0 g)
(mass Ca of 4.0 g would score 1 mark as 'ecf' as molar ratio has not been identified)

(iii) Ca has reacted with water ✓
$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ ✓✓
state symbols not required

1st mark for H_2 3
2nd mark is for the rest of the balanced equation

[6]

20. (i) moles Ti = 1.44/47.9 = 0.0301 mol/0.03 mol 1
(accept use of answer from (b))

(ii) mass of Cl = 5.70-1.44 = 4.26 g ✓
moles Cl = 4.26/35.5 = 0.120 mol ✓ 2
5.70/35.5 = 0.161 mol gets 1 mark

(iii) Ti:Cl = 0.0301 : 0.12 = 1:4.
Empirical formula = $TiCl_4$ ✓
0.0301 : 0.161 mol gives $TiCl_5$ for 1 mark 1

(iv) $Ti + 2Cl_2 \rightarrow TiCl_4$ ✓ 1
(ecf possible from (iii)
covalent ✓

[5]

21. (a) …$Mg(OH)_2(s)$ + **2**…$HCl(aq)$ → ….$MgCl_2(aq)$ + **2**…$H_2O(l)$ ✓ 1

(b) (i) moles $HCl = 0.108 \times 500/1000 = 0.054$ ✓ 1

(ii) moles $Mg(OH)_2$ = ½ × moles $HCl = 0.027$ ✓
molar mass of $Mg(OH)_2 = 24.3 + 17 \times 2 = 58.3$ ✓
(do not penalise 24)

mass $Mg(OH)_2 = 58.3 \times 0.027 = 1.57$ g / 1.5741 g ✓
(accept ans from (ii) × 0.027 = 1.566 g)
(mass $Mg(OH)_2$ of 3.15 g would score 2 marks as 'ecf' as molar ratio has not been identified) 3

(iii) Too much **if** 2.42 g (dose) > ans to (ii) ✓
(If answer to (ii) > 2.42 g then 'correct' response here would be 'Not enough' 1

[6]

22. (i) Number **AND** type of atoms (making up a molecule)/number of atoms of each element ✓ 1
Not *ratio*

(ii) $P_4 + 6\,Br_2 \rightarrow 4\,PBr_3$ ✓ 1

(iii) ratio P : Br = 16.2/31 : 83.8/79.9
/= 0.52 : 1.05
/= 1 : 2 ✓
Empirical formula = PBr_2 ✓
Correct compound = P_2Br_4 /phosphorus(II) bromide but **not** PBr_2 ✓ 3

[5]

23. (i) mass of Ni = 2.0g ✓
moles of Ni = 2.0/58.7 mol = 0.0341/0.034 mol ✓
(1 mark would typically result from no use of 25% → 0.136 mol) 2
2nd mark is for the mass of Ni divided by 58.7

(ii) number of atoms of Ni = $6.02 \times 10^{23} \times 0.0341$ 1

$= 2.05 \times 10^{22}$ / 2.1×10^{22} atoms ✓

Can be rounded down to 2.1 or 2.0 or 2 (if 2.0)

From 8 g, ans = $8.18/8.2 \times 10^{22}$

(and other consequential responses)

[3]