

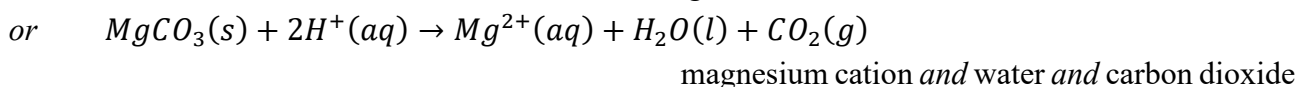
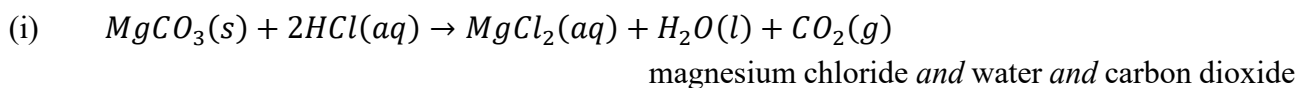
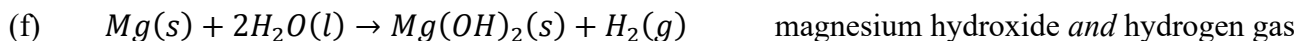
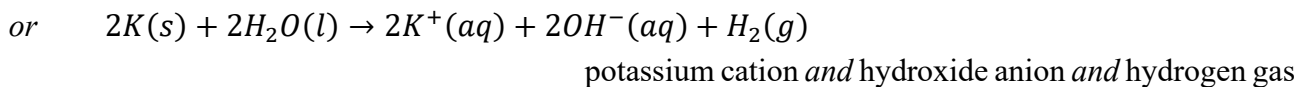
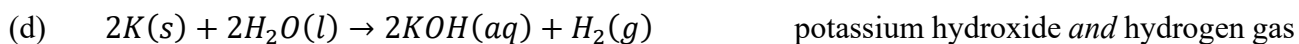
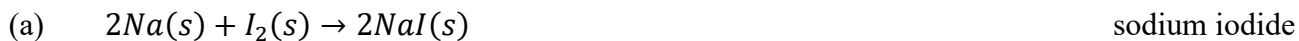
Answers to Practice Test Questions 7 More Metals and Ionic Solids

1. *Only one answer required for each blank; "/" indicates possible choices*
- (a) cobalt(II) bromide
 - (b) Mg^{2+} and Ca^{2+}
 - (c) beryllium (Be)
 - (d) Cu_3N
 - (e) aluminium oxide (Al_2O_3)
 - (f) beryllium oxide (BeO) / aluminium oxide (Al_2O_3)
or any other oxide of a group 13 element
 - (g) iron(III) oxide (Fe_2O_3)
 - (h) carbon dioxide (CO_2)
 - (i) barium carbonate (BaCO_3)
 - (j) negative

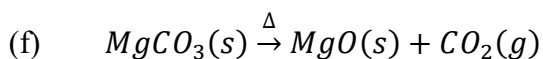
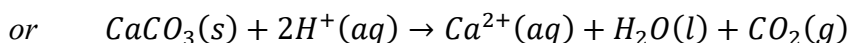
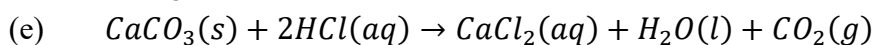
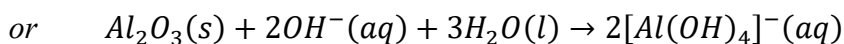
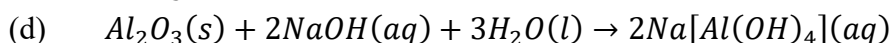
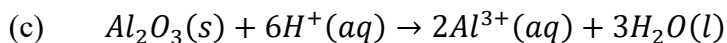
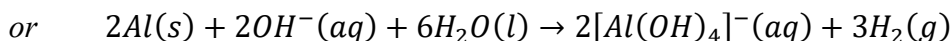
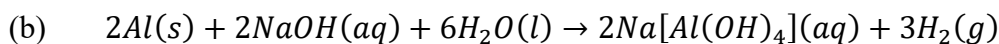
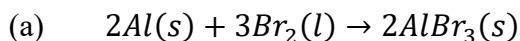
2.

Chemical Formula	Name
Na_2O	sodium oxide
Li_2S	lithium sulfide
CoCl_3	cobalt(III) chloride
Mg_3N_2	magnesium nitride
CrI_2	chromium(II) iodide
TiBr_4	titanium(IV) bromide

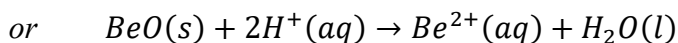
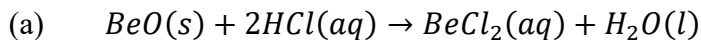
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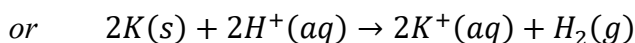
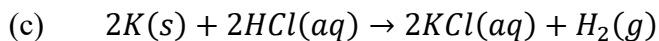
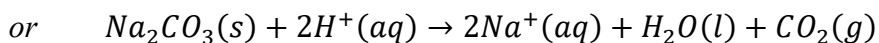
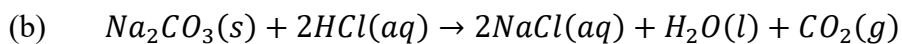
4.



5.



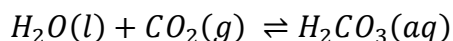
$\text{Be}^{2+}(aq)$ can also be written as $[\text{Be}(\text{OH})_2]^{2+}(aq)$. Four waters are added to the other side of the equation to make it balance. The equation must then be simplified so that only one side has water.



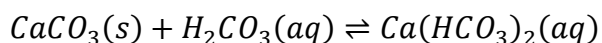
6. The beryllium oxide reaction because beryllium cations are highly toxic.
or The potassium reaction. Potassium reacts violently with water. It will react even more violently with acid. This is most likely an explosive reaction!!! *Most TAs would be more scared of this reaction (depending on the quantity of potassium used).*

7.

- (a) Hard water is water containing Ca^{2+} and/or Mg^{2+} cations.
It may also contain other cations with large positive charges. e.g. Fe^{3+}
- (b) Water dissolves minerals such as MgCO_3 or CaCO_3 as it passes through limestone, etc.
 This is possible because CO_2 from the air dissolves in water, making the water acidic:



The acidic water dissolves carbonates, making soluble bicarbonates:



- (c) Heating water reduces the solubility of gases such as CO_2 . This makes the water less acidic and some of the soluble bicarbonates are converted back to carbonates and precipitate out. This is an example of Le Châtelier's principle as removal of $\text{CO}_2(g)$ drives both equilibria shown in part (b) toward the reactant side.
- (d) Water can be softened. In other words, remove the Ca^{2+} , Mg^{2+} , etc. cations.

One way to do this is to use an ion exchange column in which anionic beads are initially saturated with Na^+ cations. When hard water passes through the ion exchange column, the $\text{Ca}^{2+}/\text{Mg}^{2+}/\text{etc.}$ cations are more strongly attracted to the anionic beads than the Na^+ cations were. So, the $\text{Ca}^{2+}/\text{Mg}^{2+}/\text{etc.}$ cations adsorb to the beads and Na^+ cations are released into the water.

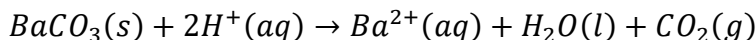
Since Na_2CO_3 is more soluble in water than CaCO_3 or MgCO_3 , it does not precipitate to the the same extent when the water is boiled and the CO_2 evaporates out of solution.

- (e) $\text{CaCO}_3(s) + 2\text{H}^+(aq) \rightarrow \text{Ca}^{2+}(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$
or $\text{CaCO}_3(s) + 2\text{H}^+(aq) \rightarrow \text{Ca}^{2+}(aq) + \text{H}_2\text{CO}_3(aq)$ *and* $\text{H}_2\text{CO}_3(aq) \rightleftharpoons \text{H}_2\text{O}(l) + \text{CO}_2(g)$
The second two equations combine to give the overall equation listed as the first answer.

8. $\text{Ca}(\text{OH})_2(s) + \text{Ca}(\text{HCO}_3)_2(aq) \rightarrow 2\text{CaCO}_3(s) + 2\text{H}_2\text{O}(l)$
or $\text{Ca}(\text{OH})_2(s) + \text{Ca}^{2+}(aq) + 2\text{HCO}_3^-(aq) \rightarrow 2\text{CaCO}_3(s) + 2\text{H}_2\text{O}(l)$

9. BaCO_3

BaCO_3 and BaSO_4 are both insoluble in water; however, BaCO_3 reacts with stomach acid, releasing toxic $\text{Ba}^{2+}(aq)$ cations:



BaSO_4 does not react with acid.

10. Pure aluminium reacts quickly with oxygen to form a thin layer of aluminium oxide on its surface. This layer of aluminium oxide does not react further with oxygen. As such, aluminium products do not rust.

This effect can be enhanced by “anodizing” the aluminium which deposits a slightly thicker film of aluminium oxide on the surface of the aluminium.

11. Use HCl.
HNO₃ is an oxidizing acid; HCl isn't.

12.

(a) beryllium oxide = ___ BeO ___ aluminium oxide = ___ Al₂O₃ ___

- (b) A strong base (concentrated hydroxide solution) is added to the mixture of solid metal oxides. The Al₂O₃(s) reacts to give the [Al(OH)₄]⁻(aq) ion while the Fe₂O₃(s) does not react. The Fe₂O₃(s) can then be filtered out of solution.

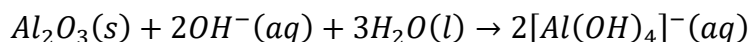
After the Fe₂O₃ has been removed, a weak acid (such as dry ice) is added to react with the [Al(OH)₄]⁻(aq) ion, giving aluminium salts (Al₂O₃ and/or Al(OH)₃ and/or AlO(OH)) which precipitate out of solution and can be isolate via filtration.

- (c) This method will not work to separate BeO and Al₂O₃.

BeO is an amphoteric oxide like Al₂O₃. The BeO will also react with the strong base, forming the [Be(OH)₄]²⁻(aq) ion. Since both species have dissolved, this method does not allow them to be separated.

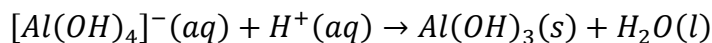
13. Al₂O₃ is an amphoteric oxide. CuO is a basic oxide (like most metal oxides except BeO and Al₂O₃).

As such, Al₂O₃ will react with base and can therefore be dissolved in aqueous base:

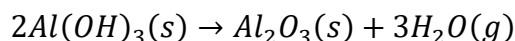


CuO will not react with aqueous base, so CuO(s) can be filtered out.

To get the Al₂O₃(s) back, add acid to neutralize the anion then heat to dehydrate and evaporate off the resulting water:



then



This is exactly the same method used to remove contaminants such as Fe₂O₃ from bauxite (see answer to question 12(b)).

14.

(a)

Method A: Dissolve each salt in water then perform a flame test on the resulting solutions. The BaCl_2 solution will give a green flame. The KCl solution will give a purple flame.

Method B: Dissolve each salt in water. Add sulfuric acid (H_2SO_4) to each solution. The one that forms a precipitate (BaSO_4) contained BaCl_2 .

There are other solutions that could be used instead of $\text{H}_2\text{SO}_4(\text{aq})$ – anything that would give an insoluble barium salt through a double replacement reaction.

(b)

Method A: Gently heat both vials. The gallium will melt at $\sim 30^\circ\text{C}$. Aluminium does not melt until much hotter (660°C).

Method B: Weigh a sample of each metal then determine its volume by displacement of a liquid. Use the mass and volume of each piece of metal to determine its density. The density of gallium is greater than the density of aluminium. (Density generally increases from top to bottom within a group.)

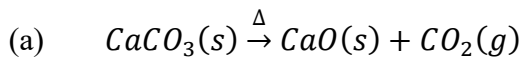
This method requires a relatively large sample of each metal so may be less practical than Method A.

(c)

Method A: Calcium reacts violently with water; zinc does not react at all with water. Set up a beaker of water behind a blast shield. Drop a small piece of one metal into the water. If there is no reaction, it was zinc. If there is a reaction producing a gas (H_2), it was calcium. Repeat the procedure with the other metal to confirm that only one reacts.

Method B: Weigh a sample of each metal then determine its volume by displacement of an inert liquid such as oil. Use the mass and volume of each piece of metal to determine its density. The density of zinc is greater than the density of calcium. *This method requires a relatively large sample of each metal so may be less practical than Method A. It has the advantage of being safer though.*

15.



m_{initial} 17.67 g

P 0.987 bar

T 297.65 K

n_{initial}	0.1765 mol	0 mol	0 mol
n_{change}	-0.1765 mol	+0.1765 mol	+0.1765 mol
n_{final}	0 mol	0.1765 mol	0.1765 mol
V_{final}	0.00443 m ³ = 4.43 L		

Step 1: Write a balanced chemical equation for the reaction

see above

Step 2: Organize all known information

see above; values in grey are not necessary for this calculation

Step 3: Calculate moles of CaCO₃ (n_{initial})

$$n_{\text{CaCO}_3\text{-initial}} = 17.67\text{g} \times \frac{1\text{mol}}{100.087\text{g}} = 0.1765\text{mol}$$

Step 4: Use mole ratio to calculate moles of CO₂ produced (n_{final})

$$n_{\text{CO}_2\text{-final}} = 0.1765\text{mol CaCO}_3 \times \frac{1\text{mol CO}_2}{1\text{mol CaCO}_3} = 0.1765\text{mol CO}_2$$

Step 5: Calculate volume of CO₂ produced in (V_{final})

$$PV = nRT$$

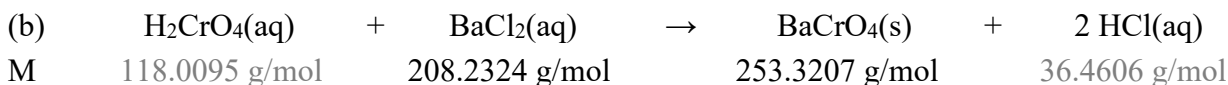
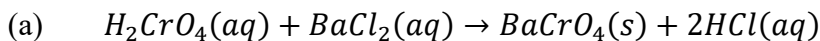
$$V_{\text{CO}_2\text{-final}} = \frac{nRT}{P} = \frac{(0.1765\text{mol})\left(8.3145\frac{\text{Pa}\cdot\text{m}^3}{\text{mol}\cdot\text{K}}\right)(297.65\text{K})}{(0.987\text{bar})} \times \frac{1\text{bar}}{10^5\text{Pa}} = 0.00443\text{m}^3$$

$$V_{\text{CO}_2\text{-final}} = 0.00443\text{m}^3 \times \frac{1000\text{L}}{1\text{m}^3} = 4.43\text{L}$$

Step 6: Check your work

Does your answer seem reasonable? Are sig. fig. correct?

16.



$m_{initial}$ 3.75 g

$c_{initial}$ 1.25 mol/L

V 75.00 mL

$n_{initial}$	0.0938 mol	0.0180 mol	0 mol	0 mol
n_{change}	-0.0180 mol	-0.0180 mol	+0.0180 mol	+0.0360 mol
n_{final}	0.0757 mol	0 mol	0.0180 mol	0.0360 mol

m_{final} 4.56 g

Step 1: Write a balanced chemical equation for the reaction

see part (a)

Step 2: Organize all known information

see above; values in grey are not necessary for this calculation

Step 3: Calculate moles of H_2CrO_4 and $BaCl_2$ ($n_{initial}$)

$$n_{BaCl_2-initial} = 3.75g \times \frac{1mol}{208.2324g} = 0.0180mol$$

$$n_{H_2CrO_4-initial} = 75.00mL \times \frac{1L}{1000mL} \times \frac{1.25mol}{1L} = 0.0938mol$$

Step 4: Identify the limiting reagent

0.0180 mol H_2CrO_4 are required to react with 0.0180 mol $BaCl_2$. Since there is more H_2CrO_4 than this, the $BaCl_2$ will run out before the H_2CrO_4 . $BaCl_2$ is therefore the limiting reagent.

Step 5: Use mole ratio to calculate moles of $BaCrO_4$ produced (n_{final})

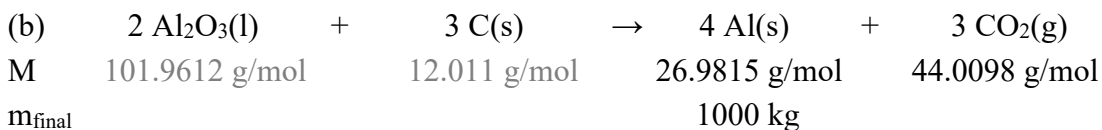
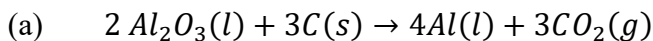
$$n_{BaCrO_4-final} = 0.0180 mol BaCl_2 \times \frac{1 mol BaCrO_4}{1 mol BaCl_2} = 0.0180 mol BaCrO_4$$

Step 6: Check your work

Does your answer seem reasonable? Are sig. fig. correct?

- (c) $BaCrO_4$ forms a stronger lattice because the charge of the chromate ion (CrO_4^{2-}) is more negative than the charge of the chloride ion (Cl^-). This means that the ion-ion attractive forces are stronger in $BaCrO_4$ than in $BaCl_2$.

17.



n_{initial}	0 mol	0 mol
n_{change}	$+3.71 \times 10^4$ mol	$+2.78 \times 10^4$ mol
n_{final}	3.71×10^4 mol	2.78×10^4 mol

Step 1: Write a balanced chemical equation for the reaction

see part (a)

Step 2: Organize all known information

see above; values in grey are not necessary for this calculation

Step 3: Calculate moles of Al produced (n_{final})

$$n_{\text{Al-final}} = 1000 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol}}{26.9815 \text{ g}} = 3.71 \times 10^4 \text{ mol}$$

Step 4: Use mole ratio to calculate moles of CO₂ produced (n_{final})

$$n_{\text{CO}_2\text{-final}} = 3.71 \times 10^4 \text{ mol Al} \times \frac{3 \text{ mol CO}_2}{4 \text{ mol Al}} = 2.78 \times 10^4 \text{ mol CO}_2$$

Step 5: Calculate mass of CO₂ produced (m_{final})

$$m_{\text{CO}_2\text{-final}} = 2.78 \times 10^4 \text{ mol CO}_2 \times \frac{44.0098 \text{ g}}{1 \text{ mol}} = 1.22 \times 10^6 \text{ g CO}_2 = 1.22 \text{ Mg CO}_2$$

Step 6: Check your work

Does your answer seem reasonable? Are sig. fig. correct?

The masses of the two products of this reaction are of the same order of magnitude (which is reasonable given that they have similar molar masses and a mole ratio of 4 : 3).