Percent Composition

1 What is the percent composition by mass of nitrogen in the compound N_2H_4 (gram-formula mass = 32 g/mol)?

(1) 13%
(2) 44%
(3) 88%
(4) 93%

2 What is the number of moles of CO_2 in a 220.-gram sample of CO_2 (gram-formula mass = 44 g/mol)?

(1) 0.20 mol
(2) 5.0 mol
(3) 15 mol
(4) 44 mol

3 What is the number of moles of KF in a 29-gram sample of the compound?

(1) 1.0 mol
(2) 2.0 mol
(3) 0.50 mol
(4) 5.0 mol

4 What is the percent composition by mass of nitrogen in $(NH_4)_2CO_3$ (gram-formula mass = 96.0 g/mol)?

(1) 14.6%
(2) 29.2%
(3) 58.4%
(4) 87.5%

Base your answers to questions 5 on the information below and on your knowledge of chemistry.

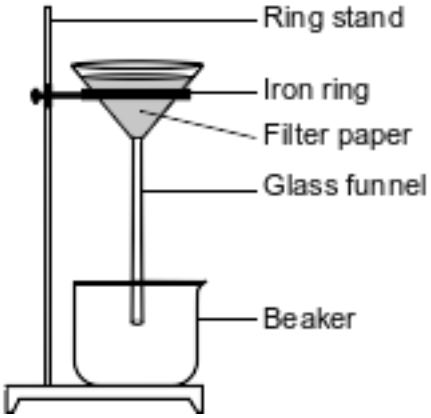
A metal worker uses a cutting torch that operates by reacting acetylene gas, $C_2H_2(g)$, with oxygen gas, $O_2(g)$, as shown in the unbalanced equation below.

$C_2H_2(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g) + \text{heat}$

5 Determine the mass of 25 moles of acetylene (gram-formula mass = 26 g/mol).

Base your answers to questions 6 on the information below and on your knowledge of chemistry.

During a laboratory activity, appropriate safety equipment is used and safety procedures are followed. A student separates a sample of rock salt that has two components; NaCl(s) and small insoluble rock particles. First, the student thoroughly stirs the sample of rock salt into a sample of water in a fl ask. The mixture in the fl ask is fi ltered using the lab apparatus shown below.



The water is evaporated from the beaker. The fi lter paper and its contents are dried. The data collected by the student are shown in the table below.

Rock Salt Separation Lab Data

Object or Material	Mass (g)
rock salt sample	16.4
filter paper	1.6
clean empty beaker	224.2
filter paper with dry rock particles	2.2
beaker with dry NaCl(s)	240.0

6 Show a numerical setup for calculating the percent by mass of NaCl in the rock salt sample.

Base your answers to questions 7 on the information below and on your knowledge of chemistry.

The enclosed cabin of a submarine has a volume of 2.4×10^5 liters, a temperature of 312 K, and a pressure of 116 kPa. As people in the cabin breathe, carbon dioxide gas, $CO_2(g)$, can build up to unsafe levels. Air in the cabin becomes unsafe to breathe when the mass of $CO_2(g)$ in this cabin exceeds 2156 grams.

7 Determine the number of moles of $CO_2(g)$ in the submarine cabin at which the air becomes unsafe to breathe. The gram-formula mass of CO_2 is 44.0 g/mol.

Base your answers to questions 8 on the information below and on your knowledge of chemistry.

A hydrate is a compound that has water molecules within its crystal structure. Magnesium sulfate heptahydrate, $MgSO_4 \cdot 7H_2O$, is a hydrated form of magnesium sulfate. The hydrated compound has 7 moles of H_2O for each mole of $MgSO_4$. When 5.06 grams of $MgSO_4 \cdot 7H_2O$ are heated to at least 300.°C in a crucible by using a laboratory burner, the water molecules are released. The sample was heated repeatedly, until the remaining $MgSO_4$ had a constant mass of 2.47 grams. During this laboratory activity, appropriate safety equipment was used and safety procedures were followed.

8 Using the lab data, show a numerical setup for calculating the percent composition by mass of water in the hydrated compound.

Base your answers to questions 9 on the information below and on your knowledge of chemistry.

During a laboratory activity, appropriate safety equipment was used and safety procedures were followed. A laboratory technician heated a sample of solid $KClO_3$ in a crucible to determine the percent composition by mass of oxygen in the compound. The unbalanced equation and the data for the decomposition of solid $KClO_3$ are shown below.

$$KClO_3(s) \rightarrow KCl(s) + O_2(g)$$

Lab Data and Calculated Results

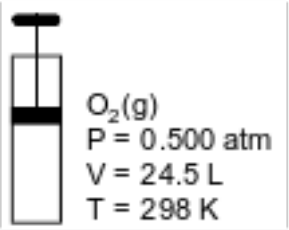
Object or Material	Mass (g)
empty crucible and cover	22.14
empty crucible, cover, and $KClO_3$	24.21
$KClO_3$	2.07
crucible, cover, and KCl after heating	23.41
KCl	?
O_2	0.80

9 Based on the lab data, show a numerical setup to determine the number of moles of O_2 produced. Use 32 g/mol as the gram-formula mass of O_2.

10 Show a numerical setup for calculating the percent composition by mass of oxygen in Al_2O_3 (gram-formula mass = 102 g/mol).

Base your answers to questions 11 on the information below and on your knowledge of chemistry.

The diagram below represents a cylinder with a moveable piston containing 16.0 g of $O_2(g)$. At 298 K and 0.500 atm, the $O_2(g)$ has a volume of 24.5 liters.



11 Determine the number of moles of $O_2(g)$ in the cylinder. The gram-formula mass of $O_2(g)$ is 32.0 g/mol.

Base your answers to questions 12 on the information below and on your knowledge of chemistry.

Some compounds of silver are listed with their chemical formulas in the table below.

Silver Compounds

Name	Chemical Formula
silver carbonate	Ag_2CO_3
silver chlorate	$AgClO_3$
silver chloride	$AgCl$
silver sulfate	Ag_2SO_4

12 Show a numerical setup for calculating the percent composition by mass of silver in silver carbonate (gram-formula mass = 276 g/mol).

Base your answers to questions 13 on the information below and on your knowledge of chemistry.

Given the unbalanced equation showing the reactants and product of a reaction occurring at 298 K and 100. kPa:

$P_4(s) + Cl_2(g) \rightarrow PCl_3(\ell)$ + energy

13 Show a numerical setup for calculating the percent composition by mass of chlorine in $PCl_3(\ell)$ (gram-formula mass = 137 g/mol).

Base your answers to questions 14 on the information below and on your knowledge of chemistry.

Wood is mainly cellulose, a polymer produced by plants. One use of wood is as a fuel in campfires, fireplaces, and wood furnaces. The molecules of cellulose are long chains of repeating units. Each unit of the chain can be represented as $C_6H_{10}O_5$. The balanced equation below represents a reaction that occurs when $C_6H_{10}O_5$ is burned in air.

$C_6H_{10}O_5 + 6O_2 \rightarrow 6CO_2 + 5H_2O$ + heat

14 Show a numerical setup for calculating the percent composition by mass of carbon in $C_6H_{10}O_5$ (gram-formula mass = 162.1 g/mol).

Base your answers to questions 15 on the information below and on your knowledge of chemistry.

Ammonia, $NH_3(g)$, can be used as a substitute for fossil fuels in some internal combustion engines. The reaction between ammonia and oxygen in an engine is represented by the unbalanced equation below.

$NH_3(g) + O_2(g) \rightarrow N_2(g) + H_2O(g) + \text{energy}$

15 Show a numerical setup for calculating the mass, in grams, of a 4.2-mole sample of O_2. Use 32 g/mol as the gram-formula mass of O_2.

Answer Keys

1 3

2 2

3 3

4 2

5 Allow 1 credit for 650 g or any value from 650 g to 651 g, inclusive.

6 Allow 1 credit. Acceptable responses include, but are not limited to:

- $\frac{(240.0\ \text{g} - 224.2\ \text{g})}{16.4\ \text{g}} \times 100$
- $\frac{(100)(15.8)}{16.4}$
- $\frac{15.8}{16.4} = \frac{x}{100}$
- $\frac{16.4 - 0.6}{16.4} \times 100$

7 Allow 1 credit for 49.0 mol or any value from 49 mol to 50. mol, inclusive.

8 Allow 1 credit. Acceptable responses include, but are not limited to:

- $\frac{5.06\ \text{g} - 2.47\ \text{g}}{5.06\ \text{g}} \times 100$

9 Allow 1 credit. Acceptable responses include, but are not limited to:

- $\frac{0.80\ \text{g}}{32\ \text{g/mol}}$

$\frac{0.80}{32}$

10 Allow 1 credit. Acceptable responses include, but are not limited to:

- $\frac{3(16\ \text{g/mol})}{102\ \text{g/mol}} \times 100$

$\frac{(15.9994 \times 3)(100)}{102}$

$\frac{48}{102} \times 100$

11 Allow 1 credit for 0.500 mol or any value from 0.500 mol to 0.501 mol, inclusive.

12 Allow 1 credit. Acceptable responses include, but are not limited to:

- $\frac{2(108\ g/mol)}{276\ g/mol} \times 100$

  $\frac{(216)(100)}{276}$

  $\frac{2(107.868)}{275.7452} \times 100$

13 Allow 1 credit. Acceptable responses include, but are not limited to:

- $\frac{3(35.5\ g/mol)}{137\ g/mol} \times 100$

  $\frac{3(35.453)}{137} \times 100$

  $\frac{106 \times 100}{137}$

  $\frac{3(35)}{136} \times 100$

14 Allow 1 credit. Acceptable responses include, but are not limited to:

- $\frac{6(12.011\ g/mol)}{162.1\ g/mol} \times 100$

  $\frac{(12\ g/mol)(6)(100)}{162.1\ g/mol}$

  $\frac{72.066}{162.1} \times 100$

15 Allow 1 credit. Acceptable responses include, but are not limited to:

- $4.2\ mol = \frac{x}{32\ g/mol}$

  $(4.2\ mol)\frac{32\ g}{1\ mol}$