Term 1 Test 2: Topic 0, 11, 1.1 (2016 - Answer Key)

Name and chemistry block: _____

There is a total of 45 points in this test. You have 5 minutes of reading time and 50 min to complete this test.

1 Multiple Choice

[1] 1. How many significant figures are in 0.08050?

A. 2

B. 4

C. 5

D. 6

Solution: The leading 2 zeroes are placeholder, its only purpose is to help express a number that is smaller than 1.

The trailing 0 *could* have been omitted, but is not omitted because the writer uses it to designate the number is **not** 0.08051 (or others). It is thus significant.

[1] 2. $(800 \pm 8) - (50 \pm 5) = ?$

A. 750 ± 3

B. 750 ± 13

C. 750 ± 75

D. 750 ± 83

Solution: In addition and subtraction, absolute uncertainties are summed.

[1] 3. $(800 \pm 8) \div (50 \pm 5) = ?$

A. $16 \pm \frac{8}{5}$

B. 16 ± 1.76

C. 16 ± 3

D. 16 ± 13

Solution: In multiplication and division, relative uncertainties are summed.

[1] 4. Precision of an experiment may be improved by:

I. repeating the experiment

II. using more precise instruments

A. I

B. II

C. I and II

D. None of the above

Solution: Both repeating the experiment and using more precise instruments *may* improve the *precision*. One targets the reproducibility uncertainty; the other targets the instrumental uncertainty.

[1] 5. Systematic errors in an experiment may be reduced by:

I. repeating the experiment

II. using more precise instruments

A. I

B. II

C. I and II

D. None of the above

Solution: Systematic errors relate to the *lack of accuracy*. Both repeating the experiment and using more precise instruments improve the *precision* but does not help with the accuracy.

[1] 6. Express 3.50 dm^3 in cm^3.

A. $3.50 \times 10^1 cm^3$

B. $3.50 \times 10^{-1} cm^3$

C. $3.50 \times 10^{-3} cm^3$

D. $3.50 \times 10^3 cm^3$

Solution: $1 dm^3 = 1 dm \times 1 dm \times 1 dm = 10 cm \times 10 cm \times 10 cm = 1000 cm^3$

[1] 7. Which of the following is considered a mixture?

A. 1.00 g of mercury $Hg^0_{(l)}$

B. 1.00 dm^3 carbon dioxide $CO_{2(g)}$

C. 1.00 mol dm^{-3} **nitric acid** $\mathbf{HNO_{3(aq)}}$

D. 1.00 mol $Ca^{2+}SO_4^{2-}{}_{(s)}$

Solution: A, C, and D are all pure substances and thus not a mixture.

An aqueous solution of $HNO_{3(aq)}$ comprises of nitric acid HNO_3 and water H_2O and is thus a mixture.

The amounts do not matter.

[1] 8. Which of the following is an example of a homogenous mixture?

A. ice $H_2O_{(s)}$

B. dry ice $CO_{2(s)}$

C. blood

D. sea water

Solution: Ice and dry ice are pure substances and thus not a mixture.

Blood is a heterogenous mixture because different regions are physically separate from one another. It is possible to centrifuge the plasma away from the solution. A bucket of sea water cannotbe separated by this physical separation.

[1] 9. A homogenous mixture can be separated by:

A. Filtration

B. Decantation (carefully pouring off some liquid)

C. Centrifugation

D. None of the above

Solution: Because the properties of a homogenous mixture is identical throughout, it is not possible to separate by mechanical processes like filtration, decantation, or centrifugation.

[1] 10. Which of the following describes $CO_{2(g)} \longrightarrow CO_{2(s)}$?

A. Freezing

B. Condensation

C. Sublimation

D. Deposition

Solution: Deposition is the phase change from gas to solid.

[1] 11. Which of the following have the same chemical properties?

I $^{37}_{17}X_{(g)}$

II $^{35}_{17}X_{2(g)}$

III $^{35}_{16}X_{2(g)}$

IV $^{37}Cl_{2(g)}$

A. I and II

B. II and IV

C. II and III

D. II, III, and IV

Solution: Differing number of protons, and different number of the element in a compound, both affects the chemical properties. A different number of neutrons do not.

I differs from II / IV because it is a single atom, as opposed to a diatomic molecule.

[1] 12. Molar mass has a unit of

I. g

II. $\frac{\text{g}}{\text{mol}}$

III. gmol^{-1}

A. I

B. I and II

C. II and III

D. None of the above

Solution: $\frac{\text{g}}{\text{mol}}$ and gmol^{-1} are identical ways of expression the same unit.

Note that in gmol^{-1} the -1 is a mathematical index. Unlike charges in chemistry, this cannot be omitted; $\text{gmol}^{-1} \neq \text{gmol}^{-}$

[1] 13. Relative molecular mass has a unit of

I. g

II. $\frac{\text{g}}{\text{mol}}$

III. gmol^{-1}

A. I

B. I and II

C. II and III

D. None of the above

Solution: Relative molecular mass, like relative atomic mass, is the ratio of the mass relative to ^{12}C. Ratios have no units.

[1] 14. Calculate the number of neutrons in $\frac{1}{4}$ mol of $^{35}\text{Cl}_{2\text{(g)}}$.

A. $(\frac{35}{4} \cdot 6.02) \times 10^{23}$

B. $(\frac{36}{4} \cdot 6.02) \times 10^{23}$

C. $(35 \cdot 6.02) \times 10^{23}$

D. $(36 \cdot 6.02) \times 10^{23}$

Solution: UPDATE

Chlorine has an atomic number of 17, *i.e.*, it has 17 protons. There is thus 35-17 = 18 neutrons in each atom, and 36 in one Cl_2. There is $\frac{1}{4}$ moles of the molecule, hence $\frac{36}{4}$ mol neutrons, or $(\frac{36}{4} \cdot 6.02) \times 10^{23}$.

[1] 15. Which of the following statements are true?

I The nucleus occupies a small volume in all atoms

II The mass of the atom is concentrated in its nucleus

III The nucleus is positively charged

A. I and II

B. I and III

C. II and III

D. I, II, and III

[1] 16. In one $^{37}_{17}Cl^{-}_{(g)}$ ion, there is a highest number of

A. Protons

B. Neutrons

C. Electrons

D. There are same number of protons, neutrons, and electrons.

Solution: Superscript on the upper right designates the charge. Negative charge designates extra electrons: there are thus 18 electrons, 17 protons, and 37-17 = 20 neutrons.

[1] 17. Calculate the moles of Al atoms present in x g of $Al_{(s)}$. The relative atomic mass of aluminium is 27.0 amu, and its atomic number is 13.

A. $x \times 13.0$

B. $x \div 13.0$

C. $x \times 27.0$

D. $x \div 27.0$

Solution: $n = \frac{m}{M} = \frac{x}{27.0}$

[1] 18. 0.500 mol of $Cl_{2(g)}$ has a mass of:

A. $\frac{35.0}{2}$

B. $\frac{35.5}{2}$

C. 35.0

D. 35.5

Solution: There is a total of 0.500mol $\times\ 2 = 1.00$mol Cl atoms.

Reading off the periodic table shows that 1.00 mol of chlorine atoms weigh 35.5 g.

[1] 19. Which formula can be determined by using only the % mass composition of an unknown compound?

I. Molecular formula

II. Structural formula

III. Empirical formula

A. I

B. II

C. III

D. I and III

Solution: Only the empirical formula can be determined. For example, only knowing that a hydrocarbon contains 85.7% of carbon by mass, we cannot distinguish between CH_2, C_2H_4, or any other molecular formula with the simplest ratio of 1:2 between carbon and hydrogen.

[1] 20. Which of the following species has the most electrons?

I. $^{35}Cl^{2-}$

II. ^{37}Cl

III. $^{35}Cl_2$

A. I

B. II

C. III

D. I and II has the same number of electrons

Solution: Cl_2 has twice the electrons as in Cl.

2 Extended responses

21. Alice prepared $BaCO_{3(s)}$ by adding $BaCl_{2(aq)}$ from a pipette into a solution of Na_2CO_3 and subsequently filtering and drying. (This is similar to the procedure you used in the preparation of $CaCO_{3(s)}$ in the lab.) She repeated the procedure three times.

[1] (a) i. State the name of the CO_3^{2-} ion

i. **carbonate**

[1] ii. Deduce the total number of protons present in **one** CO_3^{2-} ion.

ii. **30**

Solution: Since atomic number refers to the number of protons, we simply sum together $6 + (8 \times 3) = 30$.

[2] iii. Deduce the total number of electrons present in **one** CO_3^{2-} ion.

iii. **32**

Solution: The 2- charge means that there are two excess electrons, or, 30 + 2 = 32.

[1] iv. Calculate the number of electrons present in 1 mol of CO_3^{2-} ion.

iv. 1.926×10^{25}

Solution: $32 \times (6.022 \times 10^{23}) = 1.926 \times 10^{25}$

[2] v. State and explain whether $^{12}CO_3^{2-}$ and $^{14}CO_3^{2-}$ will have the same chemical reactivity.

Solution: Different only in number of neutrons, does not affect chemical reactivities.

Note that, *while I have given Benefit of Doubt in the marking*, it is not correct to say either:

1. Properties are same because number of protons is the same, or
2. Properties are same because there are same number of electrons

A He atom (2 protons, 2 electrons) is very different from H_2, which also has 2 protons and 2 electrons!

[1] (b) i. State and explain whether $Na_2CO_{3(aq)}$ is a pure substance, a homogenous mixture, or a heterogenous mixture.

Solution: Aqueous solutions are always homogenous mixtures.

[2] ii. Predict, outlining your reason, what the freezing point of $Na_2CO_{3(aq)}$ will likely be.

Solution: As an aqueous solution, most of $Na_2CO_{3(aq)}$ is water, and the freezing point will be around 0 °C.

(The actual freezing point will be below 0 °C because of a phenomena called "freezing point depression".)

(c) Alice first centrifuged the sample before using a Buchner funnel to filter the solids.

[1] i. State the precaution that must be undertaken when using a centrifuge.

Solution: The masses on opposing sides must be balanced.

- Do not accept general comments like "lab coats / safety goggles".

[2] ii. Sketch and label a filtration setup using a Buchner funnel.

Solution:

(d) For the first experiment, after filtration, Alice obtained 3.234 ± 0.002 g of a wet paste. After drying in the oven the mass decreased to 1.292 ± 0.002 g.

[1] i. Calculate the mass of the water lost. Include uncertainties and correct number of significant figures in your answer.

i. 1.942 ± 0.004g

Solution: $3.234 - 1.292 = 1.942$

For addition and subtraction, the absolute uncertainty is summed. $0.002 + 0.002 = 0.004$g.

[1] ii. Deduce the percentage of the wet paste that was water.

ii. 60.04%

Solution: $\dfrac{1.942}{3.234} \times 100\% = 60.04\%$

[2] iii. Calculate the number of moles of $BaCO_{3(s)}$ made. Include uncertainties and correct number of significant figures in your answer.

iii. 0.00655 ± 0.00002mol

Solution: $n = \dfrac{m}{M} = \dfrac{1.292\text{g}}{197.34\text{gmol}^{-1}} = 0.006547\text{mol}$

Notice that the uncertainty must *also* be in moles: $\Delta n = \dfrac{\Delta m}{M} = \dfrac{0.004}{197.34} = 0.0000202\text{mol}$

Express uncertainty to 1 significant figure, and making sure the principle value is consistent, gives 0.00655 ± 0.00002mol

[2] (e) Given the amounts of reagents used, Alice calculated that she should have made 1.500 g of $BaCO_{3(s)}$. (This is called the *theoretical yield*) Propose a reason for why her yield is lower than expected, and how this may be improved.

Solution: Reagents and products may be lost during the transfers, or passed through Buchner funnel during filtration.

- Do not accept general / vague answers such as "there is systematic error", or "there is human error"

- Award 1 mark for proposed error
- Award 1 mark for proposed solution
- Award M2 only if the solution addresses the error.

(f) The results of the three syntheses are shown in the Table 1.

Table 1 Results for the synthesis of $BaCO_{3(s)}$

	Filter paper / g (± 0.002)	Dried filter paper with $BaCO_{3(s)}$ / g (± 0.002)	Mass of $BaCO_{3(s)}$ / g
Trial 1	0.507	1.799	1.292
Trial 2	0.500	1.313	0.813
Trial 3	0.451	1.650	1.199

[1] i. Calculate the average amount of $BaCO_{3(s)}$ prepared.

i. **1.101** g

Solution:

[1] ii. Deduce the instrumental uncertainty for the mass of $BaCO_3$ prepared.

ii. **0.004**

Solution: There are both uncertainties with the filter paper, and the uncertainty with the dried filter paper c/ sample.

[1] iii. Calculate the reproducibility uncertainty from the three preparations.

iii. **0.138**

Solution: $U = \frac{max - min}{2\sqrt{N}} = \frac{1.292 - 0.813}{2\sqrt{3}} = 0.138$

[1] iv. State and explain which of the two uncertainties (from part ii and iii) should be used in reporting the yield of the synthesis.

Solution: The reproducibility uncertainty is larger, and should thus be used. We try to make claims only as good as our data allow.

[2] v. Report, *as a final value*, the amount of $BaCO_{3(s)}$ prepared by Alice's synthesis.

v. 1.1 ± 0.1 g

Solution: 1.101 ± 0.138g expressed to 1 sig fig uncertainty is 1.101 ± 0.1. Making the principle value consistent gives 1.1 ± 0.1