

1. During a laboratory activity, a student combined two solutions. In the laboratory report, the student wrote "A yellow color appeared." The statement represents the student's recorded
- A) conclusion **B) observation**
 C) hypothesis D) inference
2. During a laboratory activity to investigate reaction rate, a student reacts 1.0-gram samples of solid zinc with 10.0-milliliter samples of HCl(aq). The table below shows information about the variables in five experiments the student performed.

Reaction of Zn(s) with HCl(aq)

Experiment	Description of Zinc Sample	HCl(aq) Concentration (M)	Temperature (K)
1	lumps	0.10	270.
2	powder	0.10	270.
3	lumps	0.10	290.
4	lumps	1.0	290.
5	powder	1.0	280.

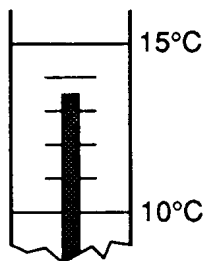
Which two experiments can be used to investigate the effect of the concentration of HCl(aq) on the reaction rate?

- A) 1 and 3 B) 1 and 5 C) 4 and 2 **D) 4 and 3**

3. Which piece of laboratory apparatus would most likely be used to evaporate a 1-milliliter sample of a solution to dryness?

- A) volumetric flask B) buret
 C) pipette **D) watch glass**

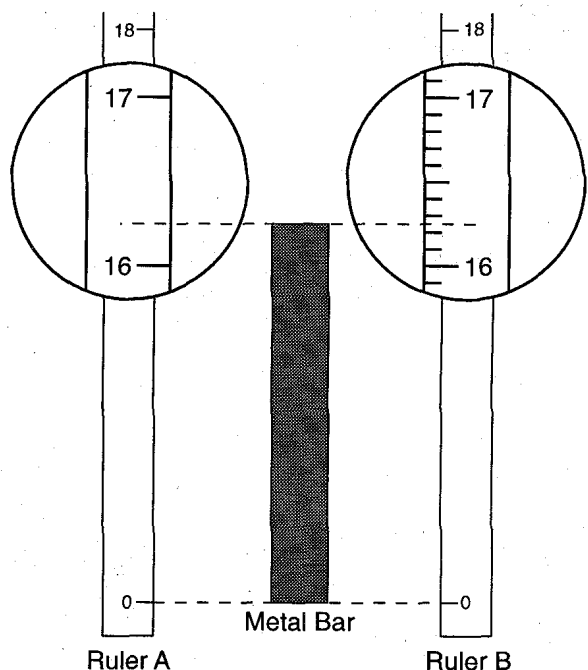
4. The diagram below represents a portion of a thermometer that is measuring the temperature of a solution.



According to the thermometer, the temperature of the solution is

- A) 13.50°C **B) 13.5°C**
 C) 16.50°C D) 16.5°C

5. The diagram below represents a metal bar and two centimeter rulers, *A* and *B*. Portions of the rulers have been enlarged to show detail.



What is the greatest degree of precision to which the metal bar can be measured by ruler *A* and by ruler *B*?

- A) to the nearest tenth by both rulers
 B) to the nearest hundredth by both rulers
C) to the nearest tenth by ruler *A* and to the nearest hundredth by ruler *B*
 D) to the nearest hundredth by ruler *A* and to the nearest tenth by ruler *B*
6. During a laboratory experiment, a sample of aluminum is found to have a mass of 12.50 grams and a volume of 4.6 milliliters.
- What is the density of this sample, expressed to the correct number of significant figures?
- A) 2.717 g/mL B) 2.72 g/mL
 C) 3 g/mL D) **2.7 g/mL**
7. A student titrates 10.00 milliliters of hydrochloric acid of unknown molarity with 1.000 M NaOH. It takes 21.17 milliliters of base to exactly neutralize the acid. If the student follows the rules for significant figures in determining the molarity of the acid, what should her answer be?
- A) 2.10 M B) 2.11 M
C) 2.117 M D) 2.120 M

8. Expressed to the correct number of significant figures, the sum of two masses is 445.2 grams. Which two masses produce this answer?
- A) 210.10 g + 235.100 g
 B) 210.100 g + 235.10 g
C) 210.1 g + 235.1 g
 D) 210.10 g + 235.10 g
9. The measurement 0.41006 gram, rounded to three significant figures, is expressed as
- A) 0.41 g **B) 0.410 g**
 C) 0.4100 g D) 0.4101 g
10. Which measurement contains three significant figures?
- A) 0.05 g B) 0.050 g
 C) 0.056 g D) **0.0563 g**
11. A student determined in the laboratory that the percent by mass of water in $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is 40.0%. If the accepted value is 36%, what is the percent of error?
- A) 0.11% B) 1.1%
C) 11% D) 4.0%
12. A student determined that the percent of H_2O in a hydrate was 39.0%. The percent of H_2O in this hydrate is 36.0% according to an accepted chemistry reference. What is the student's percent of error?
- A) 9.1% **B) 8.3%** C) 3.0% D) 11%
13. A student found the boiling point of a liquid to be 80.4°C . If the liquid's actual boiling point is 80.6°C , the experimental percent error is equal to
- A)** $\frac{80.6 - 80.4}{80.6} \times 100$
 B) $\frac{80.6 - 80.4}{80.4} \times 100$
 C) $\frac{80.5 - 80.4}{80.5} \times 100$
 D) $\frac{80.5 - 80.4}{80.4} \times 100$
14. The accepted value for the molar volume of a gas is 22.4 liters. In a laboratory experiment, a student determines the value to be 24.8 liters. What is the percent error of the student's measurement?
- A) 0.120% B) 0.107%
C) 10.7% D) 12.0%

15. In an experiment, a student found that the percent of oxygen in a sample of KClO_3 was 42.3%. If the accepted value is 39.3%, the experimental percent error is
- A) $\frac{42.3}{39.3} \times 100\%$ B) $\frac{39.3}{42.3} \times 100\%$
 C) $\frac{3.0}{42.3} \times 100\%$ D) $\frac{3.0}{39.3} \times 100\%$
16. A student wishes to prepare approximately 100 milliliters of an aqueous solution of 6 M HCl using 12 M HCl. Which procedure is correct?
- A) **adding 50 ml of 12 M HCl to 50 ml of water while stirring the mixture steadily**
 B) adding 50 ml of 12 M HCl to 50 ml of water, and then stirring the mixture steadily
 C) adding 50 ml of water to 50 ml of 12 M HCl while stirring the mixture steadily
 D) adding 50 ml of water to 50 ml of 12 M HCl, and then stirring the mixture steadily
17. Which activity is considered a proper laboratory technique?
- A) heating the contents of an open test tube held vertically over a flame
 B) heating the contents of a test tube that has been closed with a stopper
 C) adding water to concentrated acids
 D) **adding concentrated acids to water**
18. What is the safest method for diluting concentrated sulfuric acid with water?
- A) add the acid to the water quickly
 B) add the water to the acid quickly
 C) **add the acid to the water slowly while stirring**
 D) add the water to the acid slowly while stirring

Base your answers to questions 19 through 21 on the information below.

A student, wearing chemical safety goggles and a lab apron, is to perform a laboratory test to determine the pH value of two different solutions. The student is given one bottle containing a solution with a pH of 2.0 and another bottle containing a solution with a pH of 5.0. The student is also given six dropping bottles, each containing a different indicator listed in Reference Table M.

19. Compare the hydronium ion concentration of the solution having a pH of 2.0 to the hydronium ion concentration of the other solution given to the student.
20. Identify an indicator in Reference Table M that would differentiate the two solutions.
21. State *one* safety precaution, *not* mentioned in the passage, that the student should take while performing tests on the samples from the bottles.

Regents review Math & measurement

Base your answers to questions **22** through **24** on the information below.

A method used by ancient Egyptians to obtain copper metal from copper(I) sulfide ore was heating the ore in the presence of air. Later, copper was mixed with tin to produce a useful alloy called bronze.

22. A 133.8-gram sample of bronze was 10.3% tin by mass. Determine the total mass of tin in the sample.
 23. Convert the melting point of the metal obtained from copper(I) sulfide ore to degrees Celsius.
 24. Calculate the density of a 129.5-gram sample of bronze that has a volume of 14.8 cubic centimeters. Your response must include a correct numerical setup and the calculated result.
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25. Base your answer to the following question on the following information.

Carbon and oxygen are examples of elements that exist in more than one form in the same phase.

Graphite and diamond are two crystalline arrangements for carbon. The crystal structure of graphite is organized in layers. The bonds between carbon atoms within each layer of graphite are strong. The bonds between carbon atoms that connect different layers of graphite are weak because the shared electrons in these bonds are loosely held by carbon atoms. The crystal structure of diamond is a strong network of atoms in which the shared electrons are strongly held by the carbon atoms. Graphite is an electrical conductor, but diamond is not. At 25°C, graphite has a density of 2.2 g/cm³ and diamond a density of 3.51 g/cm³.

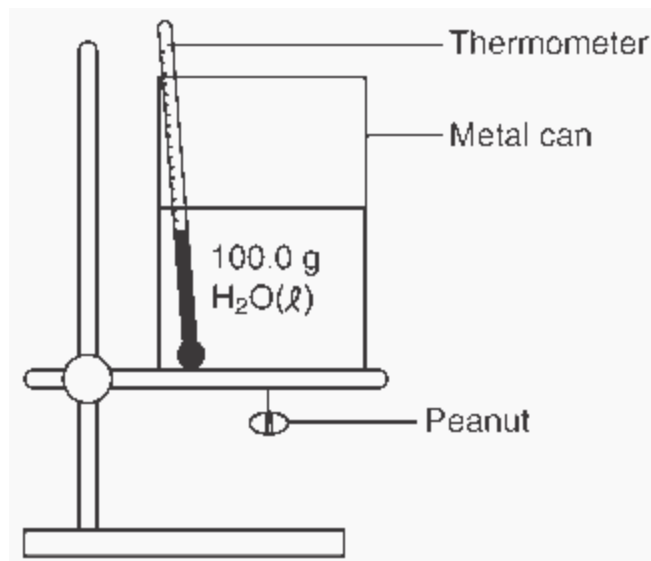
The element oxygen can exist as diatomic molecules, O₂, and as ozone, O₃. At standard pressure the boiling point of ozone is 161 K.

Calculate the volume, in cm³, of a diamond at 25°C that has a mass of 0.200 gram. Your response must include both a correct numerical setup and the calculated result.

26. Base your answer to the following question on the information below.

A student performed an experiment to determine the total amount of energy stored in a peanut. The accepted value for the energy content of a peanut is 30.2 kilojoules per gram. The student measured 100.0 grams of water into a metal can and placed the can on a ring stand, as shown in the diagram below. The peanut was attached to a wire suspended under the can.

The initial temperature of the water was recorded as 22.0° C. The peanut was ignited and allowed to burn. When the peanut finished burning, the final water temperature was recorded as 57.0° C. The student's experimental value for the energy content of this peanut was 25.9 kilojoules per gram.



Determine the student's percent error for the energy content of this peanut.

27. A student used a balance and a graduated cylinder to collect the following data:

Sample mass	10.23 g
Volume of water	20.0 mL
Volume of water and sample	21.5 mL

a Calculate the density of the element. Show your work. Include the appropriate number of significant figures and proper units.

b If the accepted value is 6.93 grams per milliliter, calculate the percent error.

c What error is introduced if the volume of the sample is determined first?

Base your answers to questions **28** and **29** on the information below.

A hydrate is a compound that has water molecules within its crystal structure. The formula for the hydrate $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$ shows that there are five moles of water for every one mole of $\text{CuSO}_4(\text{s})$. When $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$ is heated, the water within the crystals is released, as represented by the balanced equation below.



A student first masses an empty crucible (a heat-resistant container). The student then masses the crucible containing a sample of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$. The student repeatedly heats and masses the crucible and its contents until the mass is constant. The student's recorded experimental data and calculations are shown below.

Data and calculation before heating:

mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$ and crucible	21.37 g
– mass of crucible	19.24 g
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mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$	2.13 g

Data and calculation after heating to a constant mass:

mass of $\text{CuSO}_4(\text{s})$ and crucible	20.61 g
– mass of crucible	19.24 g
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mass of $\text{CuSO}_4(\text{s})$	1.37 g

Calculation to determine the mass of water:

mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$	2.13 g
– mass of $\text{CuSO}_4(\text{s})$	1.37 g
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mass of $\text{H}_2\text{O}(\text{g})$	0.76 g

28. Explain why the sample in the crucible must be heated until the constant mass is reached.

29. Identify the total number of significant figures recorded in the calculated mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$.

30. Base your answer to the following question on the information below.

The accepted values for the atomic mass and percent natural abundance of each naturally occurring isotope of silicon are given in the data table below.

Naturally Occurring Isotopes of Silicon

Isotope	Atomic Mass (atomic mass units)	Percent Natural Abundance (%)
Si-28	27.98	92.22
Si-29	28.98	4.69
Si-30	29.97	3.09

A scientist calculated the percent natural abundance of Si-30 in a sample to be 3.29%. Determine the percent error for this value.

Answer Key

Regents review Math & measurement 2011-2012

1. **B**
2. **D**
3. **D**
4. **B**
5. **C**
6. **D**
7. **C**
8. **C**
9. **B**
10. **D**
11. **C**
12. **B**
13. **A**
14. **C**
15. **D**
16. **A**
17. **D**
18. **C**
19. Acceptable responses include, but are not limited to: • The hydronium ion concentration is 1000 times greater in the solution having a pH of 2.0. • The other solution has a lower H⁺ ion concentration.
20. Acceptable responses include, but are not limited to: methyl orange
21. Acceptable responses include, but are not limited to: • Wear protective gloves. • Avoid spills.
Note: Do *not* allow credit for “wearing goggles” or “wearing an apron.”

22. Example: 13.8 g
23. Answer: 1084°C
24.
$$d = \frac{m}{V} = \frac{129.5 \text{ g}}{14.8 \text{ cm}^3}$$
25.
$$V = \frac{m}{d} = \frac{0.200 \text{ g}}{3.51 \text{ g/cm}^3}$$

$$\frac{0.200 \text{ g}}{\quad} \bigg| \frac{1 \text{ cm}^3}{3.51 \text{ g}}$$

$$\frac{0.2}{3.51}$$
26. -14% *or* 14%.
27. a) Examples:
 $\frac{10.23}{21.5-20.0} c \geq 6.8$
or,
 $\frac{10.23}{1.5} c \geq 6.8$ or,
 $\frac{10.23 \text{ g}}{1.5 \text{ ml}} c \geq 6.8 \text{ g/ml}$
and accept only to the nearest tenth with a range from 6.7 - 6.9

Proper Units: g/ml or grams per milliliter

b) Range of 1.8 - 2.0%
c) The density would increase because the sample was wet when weighed
28. *Examples:* – Until the samples reaches a constant mass, the student cannot be sure that all the water has been removed. – to make sure all the water is heated out of the sample
29. 3
30. 6.5%