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– Students should use the CEF’s periodic table ([competition version](#)) –

1. Maria is a pharmacist at a healthcare company who wants to test two different medicines to see which is more effective at relieving headaches. She divides the test subjects into 3 groups and gives each group different pills as shown in the table below.

Group Number	Medicine Type
1	Medicine X
2	Medicine Y
3	Placebo (no medicine)

In terms of experimental design, what is the name given to the third group that receives pills with no medicine (placebo pills)?

2. Raul is a safety engineer who is conducting an experiment to determine whether heavier objects fall faster than lighter objects.

What is the independent variable in his experiment?

3. Soluble salts and minerals accumulate in the Dead Sea due to continuous water evaporation and lack of drainage. As a result of the high concentration of salts, humans can float more easily in the Dead Sea than in other bodies of water.

What physical property of the water is affected by the dissolved salts, thereby allowing humans to float more easily?

4. Janelle measures her height five times as shown in the table below. The following week, while at a baseball camp, the physical therapist measures her height every day.

Measurement Taker	Monday	Tuesday	Wednesday	Thursday	Friday
Janelle	190.2 cm	190.2 cm	190.0 cm	189.8 cm	189.9 cm
Physical Therapist	181.2 cm	181.1 cm	180.9 cm	181.0 cm	180.9 cm

Assuming the physical therapist's measurements are both precise and accurate, are Janelle's measurements precise, accurate, or both precise and accurate?

Please answer precise, accurate, or both.

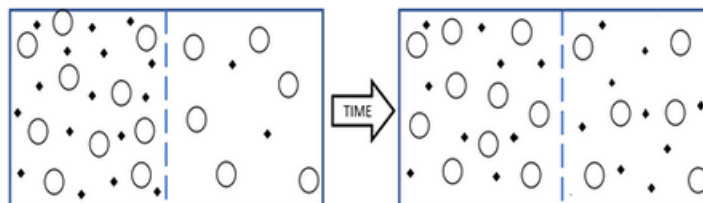
5. A widely used automobile fuel called gasohol is produced by mixing ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) with gasoline.

How many atoms of carbon are there in 6 molecules of ethanol?

6. Which of the following equations represents a decomposition reaction?

- A. $(\text{NH}_4)_2\text{S} + 2\text{AgNO}_3 \rightarrow \text{Ag}_2\text{S} + 2\text{NH}_4\text{NO}_3$
- B. $2\text{HCl} + \text{Ba}(\text{OH})_2 \rightarrow 2\text{H}_2\text{O} + \text{BaCl}_2$
- C. $2\text{Al} + 3\text{Cu}(\text{NO}_3)_2 \rightarrow 2\text{Al}(\text{NO}_3)_3 + 3\text{Cu}$
- D. $(\text{NH}_4)_2\text{CO}_3 \rightarrow 2\text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O}$

7. Two solutions, prepared with the same two solutes in different concentrations in the same solvent, are placed on 2 sides of a semi-permeable barrier in a closed container. The system is left undisturbed for a period of time.



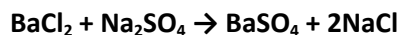
What process is illustrated in the diagram above?

8. P_4S_9 is one of several sulfides formed from phosphorous and sulfur.

What is the IUPAC name of P_4S_9 ?

- A. Tetraphosphorous novasulfide
- B. Hexaphosphorous nonasulfide
- C. Quadriphosphorous novasulfide
- D. Tetraphosphorous nonasulfide

9. Barium sulfate is an insoluble solid that is provided to patients with digestive problems as a thick, opaque drink containing fine particles of the barium sulfate evenly suspended in water. One method to produce barium sulfate for medical use is to react barium chloride and sodium sulfate in the following reaction:



What is the name for this type of reaction?

10. A forest fire is difficult to stop in a large, dry forest because all three conditions needed for fire to occur are met.



Which of the three conditions is satisfied by the dry wood in the forest?

11. Calcium chloride (CaCl_2) is a compound commonly used as a “de-icer” to keep streets safe in cold, inclement weather.



What type of bonding occurs in the compound calcium chloride?

12. Elemental phosphorus was the main chemical in the original striking match. Imagine that a neutral atom of phosphorus gains enough electrons to fill its valence shell.



How many electrons does the neutral atom of phosphorus gain to reach a full valence shell and what is its charge with a full valence shell?

13. Which isotope of hydrogen diffuses the fastest at standard temperature and pressure?

- A. Deuterium
- B. Protium
- C. Tritium
- D. All three diffuse at the same rate

14. Which particle has the greatest positive nuclear charge?

- A. A calcium 2+ ion
- B. An oxygen 2- ion
- C. A hydrogen 1+ ion
- D. An iodide 1- ion

15. How many electrons are shared in one molecule of O_2

- A. 0
- B. 2
- C. 4
- D. 6

16. Electrons with a principal quantum number of 2 are located in what type of orbital?

- A. A d orbital
- B. A p orbital
- C. An s orbital
- D. Either B or C

17. Which ion has eight valence electrons?

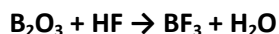
- A. B^+
- B. Li^+
- C. N^{3-}
- D. Both B and C

18. Gustavo is biochemist conducting research on a process that decreases the mass of an atom's nucleus.

Which of the following could Gustavo be researching?

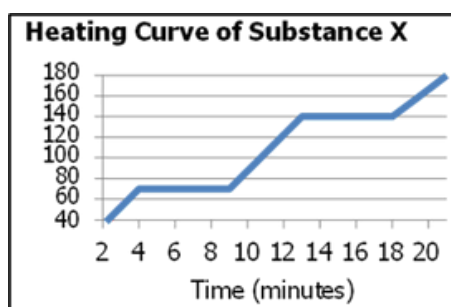
- A. Alpha decay
- B. Gamma decay
- C. Ionic bonding
- D. Nuclear fusion

19. Boron trifluoride is an important industrial catalyst formed by the unbalanced chemical equation shown below.



What coefficient should be added to hydrogen fluoride to balance the equation?

- A. 2
 - B. 3
 - C. 4
 - D. 6
20. A balanced chemical equation contains $4\text{NH}_3 + 5\text{O}_2$ as reactants. How many atoms of oxygen and hydrogen are found in the products?
- A. 2 oxygen, 3 hydrogen
 - B. 5 oxygen, 7 hydrogen
 - C. 5 oxygen, 12 hydrogen
 - D. 10 oxygen, 12 hydrogen
21. A forensic investigator heats the solid form of substance X in the lab until it is entirely a gas, as shown in the graph at right of the substance's temperature versus time.



What is the approximate freezing point of the substance?

22. The safety diamond for a chemical sample is shown below.



Based on this safety diamond, which of the following four hazards must be taken into account when handling or storing the chemical sample?

- A. Health
- B. Flammability
- C. Reactivity
- D. Radioactivity

23. Erica is a nutritionist studying phosphoric acid, which is used in the food industry because it helps prevent the growth of mold and bacteria in sugary solutions.

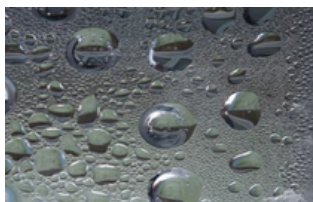
Erica needs to determine the chemical equation for the decomposition of phosphoric acid. Which of the following is the correct chemical equation?

- A. $\text{H}_3\text{PO}_4 \rightarrow \text{H}_2\text{O} + \text{HPO}_3$
- B. $\text{PH}_3 \rightarrow \text{PH} + \text{H}_2$
- C. $\text{H}_3\text{PO}_4 + \text{MgO} \rightarrow \text{MgHPO}_4 + \text{H}_2\text{O}$
- D. $\text{H}_3\text{PO}_4 + \text{Mg} \rightarrow \text{MgPO}_4^{-1} + \text{H}_2$

24. Mendelevium-257 is a radioactive isotope with a half-life of 5.5 hours. How much of a 60 mg sample of mendelevium-257 will remain after 16.5 hours?

- A. 3.8 mg
- B. 7.5 mg
- C. 15 mg
- D. 30 mg

25. A closed system contains an unknown gas.



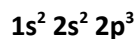
What change in the pressure of the closed system will cause the gas to condense?

26. Methanol, CH_3OH , is used to fuel internal combustion engines and was previously the fuel required for cars racing in the Indianapolis 500.

What is the total number of valence electrons in one molecule of methanol?

- A. 4
- B. 6
- C. 12
- D. 14

27. A neutral atom of an element has the electron configuration below.



What is the name of this element?

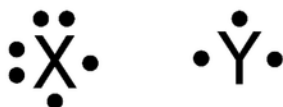
28. Which of the structures below is the correct Lewis structure for a bromide ion?



29. Geologists can determine the age of a carbon containing sample from an archaeological dig of an ancient human settlement by calculating how much carbon-14 isotope has radioactively decayed into nitrogen-14 from the sample since the animal or plant died.

What type of particle does carbon-14 emit during radioactive decay?

30. The Lewis symbols of elements X and Y are shown below.



What is the chemical formula of the ionic compound formed between X and Y?

- A. X_2Y_3
- B. X_3Y_2
- C. YX_2
- D. Y_2X_3

1. Control OR Control Group
2. Mass OR weight OR the objects' mass OR the objects' weight
3. Density
4. Precise
5. 12 OR 12 atoms
6. D
7. Diffusion
8. D
9. Double Displacement OR Double Replacement OR Precipitation
10. Fuel
11. Ionic OR ionic bonding
12. 3, -3 OR 3 electrons, -3 charge
13. B
14. D
15. C
16. D
17. C
18. A
19. D
20. D
21. 70 °C
22. D
23. A
24. B
25. Increase OR Increase in pressure
26. D
27. Nitrogen
28. C
29. Beta particle OR electron
30. D