1. Which pair represents two forms of an element in the same phase but with different structures and different properties?

   A) $I_2(s)$ and $I_2(g)$
   B) $O_2(g)$ and $O_3(g)$
   C) $H_2(g)$ and $Hg(g)$
   D) $H_2(s)$ and $H_2O(\ell)$

2. Compared to a 26-gram sample of $NaCl(s)$ at STP, a 52-gram sample of $NaCl(s)$ at STP has

   A) a different density
   B) a different gram-formula mass
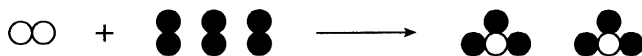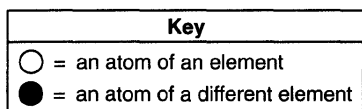   **C) the same chemical properties**
   D) the same volume

3. At STP, which physical property of aluminum always remains the same from sample to sample?

   A) mass
   B) density
   C) length
   D) volume

4. Which sample of CO_2 has a definite shape and a definite volume?

   A) $CO_2(aq)$
   B) $CO_2(g)$
   C) $CO_2(\ell)$
   D) $CO_2(s)$

5. Given the balanced particle-diagram equation:

   Key
   ○ = an atom of an element
   ● = an atom of a different element

   ∞ + ●●●●●● ⟶ ●●● ●●●

   Which statement describes the type of change and the chemical properties of the product and reactants?

   A) The equation represents a physical change, with the product and reactants having different chemical properties.
   B) The equation represents a physical change, with the product and reactants having identical chemical properties.
   C) The equation represents a chemical change, with the product and reactants having different chemical properties.
   D) The equation represents a chemical change, with the product and reactants having identical chemical properties.
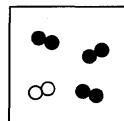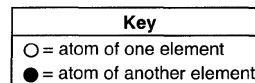
6. Particles are arranged in a crystal structure in a sample of

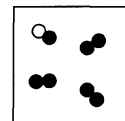   A) $H_2(g)$ B) $Br_2(l)$ C) $Ar(g)$ **D) $Ag(s)$**

7. Which substance can be broken down by chemical means?
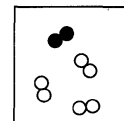
   A) CO   B) Ce   C) Ca   D) Cu

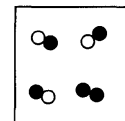8. Which two particle diagrams represent mixtures of diatomic elements?

   Key
   ○ = atom of one element
   ● = atom of another element

   A   B   C   D

   A) A and B
   B) A and C
   C) B and C
   D) B and D

9. Which grouping of the three phases of bromine is listed in order from left to right for increasing distance between bromine molecules?

   A) gas, liquid, solid
   B) liquid, solid, gas
   C) solid, gas, liquid
   D) solid, liquid, gas

10. A 10.0-gram sample of $H_2O(\ell)$ at 23.0°C absorbs 209 joules of heat. What is the final temperature of the $H_2O(\ell)$ sample?

    A) 5.0°C
    B) 18.0°C
    C) 28.0°C
    D) 50.0°C

11. Which phase change results in the release of energy?

    A) $H_2O(s) \rightarrow H_2O(\ell)$
    B) $H_2O(s) \rightarrow H_2O(g)$
    C) $H_2O(\ell) \rightarrow H_2O(g)$
    D) $H_2O(g) \rightarrow H_2O(\ell)$

12. Which process is exothermic?

    A) boiling of water
    B) melting of copper
    C) condensation of ethanol vapor
    D) sublimation of iodine

13. Which statement defines the temperature of a sample of matter?

    A) Temperature is a measure of the total electromagnetic energy of the particles.
    B) Temperature is a measure of the total thermal energy of the particles.
    C) Temperature is a measure of the average potential energy of the particles.
    D) Temperature is a measure of the average kinetic energy of a particles.

14. A gas changes directly to a solid during

    A) fusion
    B) deposition
    C) saponification
    D) decomposition

15. The graph below represents the relationship between time and temperature as heat is added at a constant rate to a sample of a substance.
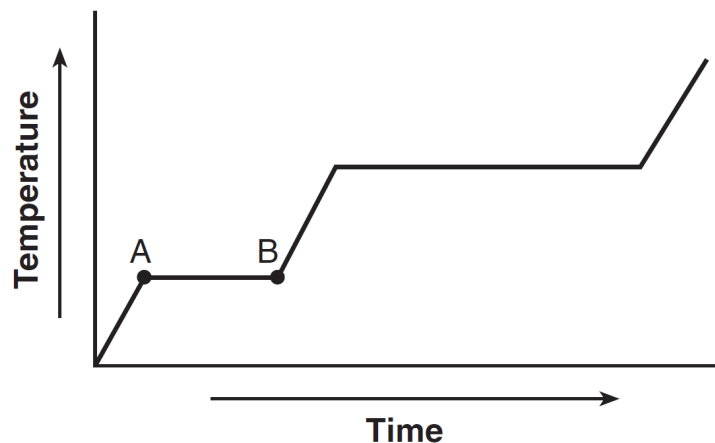

During interval *AB* which energy change occurs for the particles in this sample?

A) The potential energy of the particles increases.
B) The potential energy of the particles decreases.
C) The average kinetic energy of the particles increases.
D) The average kinetic energy of the particles decreases.

16. Which sample of water contains particles having the highest average kinetic energy?

A) 25 mL of water at 95°C
B) 45 mL of water at 75°C
C) 75 mL of water at 75°C
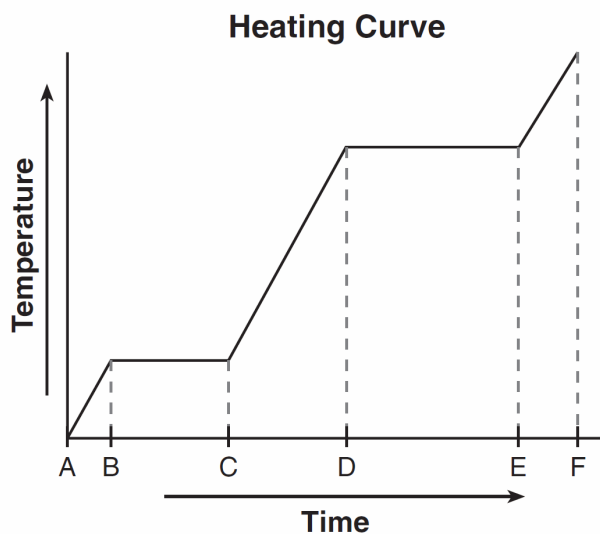D) 95 mL of water at 25°C

17. The graph below represents the heating curve of a substance that starts as a solid below its freezing point.
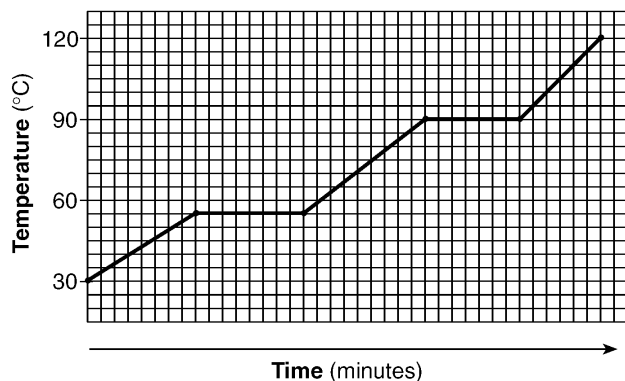
What is the melting point of this substance?

A) 30°C **B) 55°C** C) 90°C D) 120°C

18. The freezing point of bromine is

A) 539°C
C) 7°C
B) −539°C
D) −7°C

19. Given the diagram representing a heating curve for a substance:
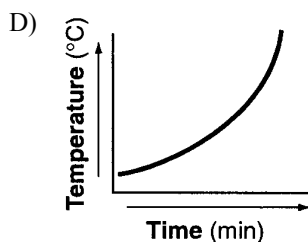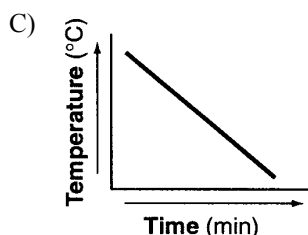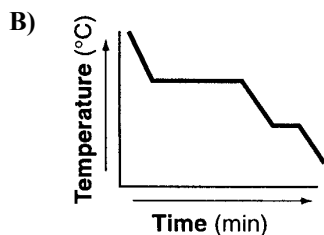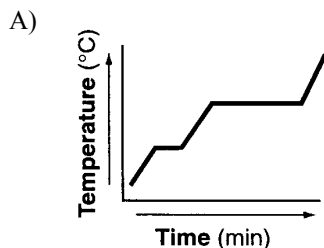
Heating Curve

During which time interval is the average kinetic energy of the particles of the substance constant while the potential energy of the particles increases?
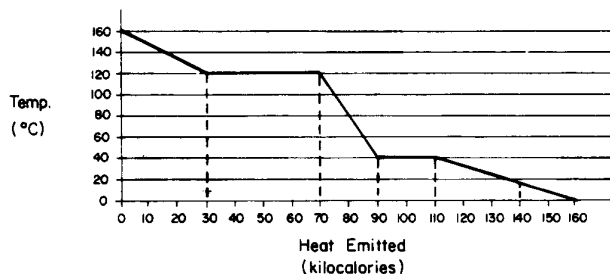
A) *AC* **B) *BC*** C) *CD* D) *DF*

20. Which graph could represent the uniform cooling of a substance, starting with the gaseous phase and ending with the solid phase?
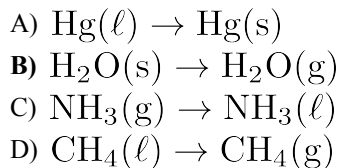
A)

B)

C)

D)

21. The graph below represents the uniform cooling of a substance, starting as a gas at 160°C. At which temperature does a phase change occur for this substance?

A) 0°C   **B) 40°C**   C) 80°C   D) 140°C

22. Which phase change is endothermic?

A) H₂O(ℓ) → H₂O(g)   B) I₂(g) → I₂(s)

C) Hg(ℓ) → Hg(s)   D) H₂S(g) → H₂S(ℓ)

23. Which equation represents sublimation?

A) $Hg(\ell) \rightarrow Hg(s)$
B) $H_2O(s) \rightarrow H_2O(g)$
C) $NH_3(g) \rightarrow NH_3(\ell)$
D) $CH_4(\ell) \rightarrow CH_4(g)$

24. Which sample of matter sublimes at room temperature and standard pressure?

A) Br₂(ℓ)   B) Cl₂(g)

C) CO₂(s)   D) SO₂(aq)

25. Which statement explains why Br₂ is a liquid at STP and I₂ is a solid at STP?

A) Molecules of Br₂ are polar, and molecules of I₂ are nonpolar.

B) Molecules of I₂ are polar, and molecules of Br₂ are nonpolar.

C) Molecules of Br₂ have stronger intermolecular forces than molecules of I₂ .

D) Molecules of I₂ have stronger intermolecular forces than molecules of Br₂ .

26. The table below shows the normal boiling point of four compounds.

Compound	Normal Boiling Point($^\circ$C)
$HF(\ell)$	19.4
$CH_3Cl(\ell)$	−24.2
$CH_3F(\ell)$	−78.6
$HCl(\ell)$	−83.7

Which compound has the strongest intermolecular forces?

A) HF(ℓ)   B) CH₃Cl(ℓ)

C) CH₃F(ℓ)   D) HCl(ℓ)

27. Two grams of potassium chloride are completely dissolved in a sample of water in a beaker. This solution is classified as

A) an element

B) a compound

C) a homogeneous mixture

D) a heterogeneous mixture

28. Which formula represents a mixture?

A) C₆H₁₂O₆(ℓ)   B) C₆H₁₂O₆(s)

C) LiCl(aq)   D) LiCl(s)

29. An example of a heterogeneous mixture is

A) soil   B) sugar

C) carbon monoxide   D) carbon dioxide

30. The table below shows the data collected by a student as heat was applied at a constant rate to a solid below its freezing point.

Time (min)	Temperature (°C)	Time (min)	Temperature (°C)
0	20	18	44
2	24	20	47
4	28	22	51
6	32	24	54
8	32	26	54
10	32	28	54
12	35	30	54
14	38	32	58
16	41	34	62

What is the boiling point of this substance?

A) 32°C **B) 54°C** C) 62°C D) 100°C

31. Which particle diagram represents a mixture of an element and a compound?

Key
○ = an atom of an element
● = an atom of a different element

A)

B)

C)

D)

32. Bronze contains 90 to 95 percent copper and 5 to 10 percent tin. Because these percentages can vary, bronze is classified as

A) a compound B) an element
C) a mixture D) a substance

33. At room temperature, a mixture of sand and water can be separated by

A) ionization B) combustion
C) filtration D) sublimation

34. An aqueous solution of sodium chloride is best classified as a

A) homogeneous compound
B) homogeneous mixture
C) heterogeneous compound
D) heterogeneous mixture

35. One similarity between all mixtures and compounds is that both

A) are heterogeneous
B) are homogeneous
C) combine in a definite ratio
D) consist of two or more substances

36. Two substances in a mixture differ in density and particle size. These properties can be used to

A) separate the substances
B) chemically combine the substances
C) determine the freezing point of the mixture
D) predict the electrical conductivity of the mixture

37. Petroleum can be separated by distillation because the hydrocarbons in petroleum are

A) elements with identical boiling points
B) elements with different boiling points
C) compounds with identical boiling points
D) compounds with different boiling point

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

    Cold packs are used to treat minor injuries. Some cold packs contain $NH_4NO_3(s)$ and a small packet of water at room temperature before activation. To activate this type of cold pack, the small packet must be broken to mix the water and $NH_4NO_3(s)$. The temperature of this mixture decreases to approximately 2°C and remains at this temperature for 10 to 15 minutes.

    Identify the type of mixture formed when the $NH_4NO_3(s)$ is completely dissolved in the water.

---

39. Describe diagrams *X, Y,* and *Z* using the following terms:

    Pure substance
    Compound
    Element
    Mixture of elements
    Mixture of compounds

    You may use more than one term for each diagram.

X   Y   Z
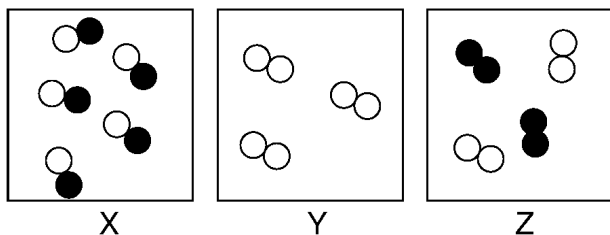
Key
Atom of element A = ○
Atom of element B = ●

    X _____

    Y _____

    Z _____

40. Which sample of matter can be separated into different substances by physical means?

    A) LiCl(aq)   B) LiCl(s)
    C) $NH_3(g)$ D) $NH_3(\ell)$

41. A beaker contains both alcohol and water. These liquids can be separated by distillation because the liquids have different

    A) boiling points   B) densities
    C) particle sizes   D) solubilities

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

    Natural gas is a mixture that includes butane, ethane, methane, and propane. Differences in boiling points can be used to separate the components of natural gas. The boiling points at standard pressure for these components are listed in the table below.

Data Table

Component of Natural Gas	Boiling Point at Standard Pressure (°C)
butane	−0.5
ethane	−88.6
methane	−161.6
propane	−42.1

    List the *four components of natural gas in order of increasing strength of intermolecular forces.*

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

    Nitrogen gas and oxygen gas make up about 99% of Earth's atmosphere. Other atmospheric gases include argon, carbon dioxide, methane, ozone, hydrogen, etc.
    The amount of carbon dioxide in the atmosphere can vary. Data for the concentration of $CO_2(g)$ from 1960 to 2000 are shown in the table below.

Atmospheric Concentration of $CO_2(g)$

Year	Concentration (ppm)
1960	316.9
1980	338.7
2000	369.4

Explain, in terms of types of matter, why methane can be broken down by chemical means, but argon can *not* be broken down by chemical means. Your response must include *both methane and argon.*

Base your answers to questions **44** and **45** on the information below.

Starting as a gas at 206°C, a sample of a substance is allowed to cool for 16 minutes. This process is represented by the cooling curve below.
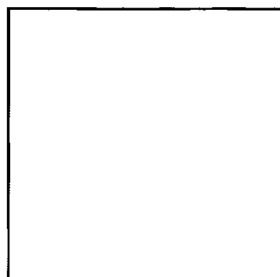
Cooling Curve for a Substance
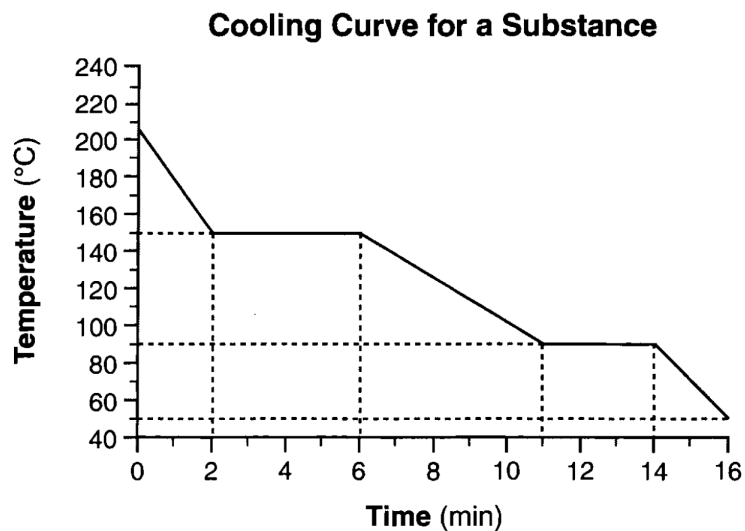
44. Using the key below, draw *two* particle diagrams to represent the *two* phases of the sample at minute 4. Your response must include *at least six* particles for *each* diagram.

Key
◯ = particle of the substance
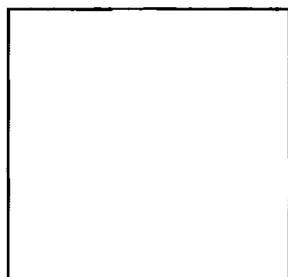
One phase of the
sample at minute 4

A different phase
of the sample
at minute 4

45. At what time do the particles of this sample have the *lowest* average kinetic energy?

_____

1. __B__

2. __C__

3. __B__

4. __D__

5. __C__

6. __D__

7. __A__

8. __B__

9. __D__

10. __C__

11. __D__

12. __C__

13. __D__

14. __B__

15. __A__

16. __A__

17. __B__

18. __D__

19. __B__

20. __B__

21. __B__

22. __A__

23. __B__

24. __C__

25. __D__

26. __A__

27. __C__

28. __C__

29. __A__

30. __B__

31. __D__

32. __C__

33. __C__

34. __B__

35. __D__

36. __A__

37. __D__

38. Acceptable responses include, but are not limited to: • homogeneous • solution

39. Answer

40. __A__

41. __A__

42.

43. –Methane is a compound consisting of two elements, so it can be broken down by chemical means, but argon is an element, which cannot be broken down.
   –Methane is a compound and argon is an element.

44.
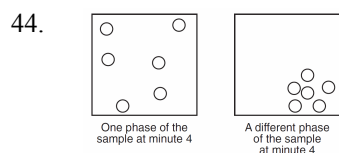
45. minute 16 or at 16 minutes