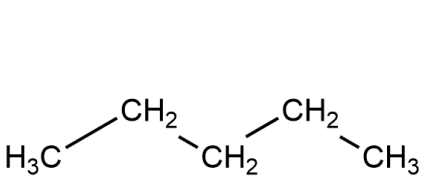
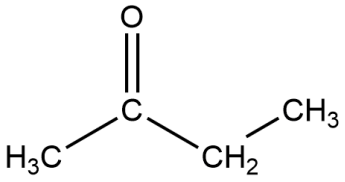
1. Which state of matter is characterized by a definite volume, a definite shape, and strong intermolecular forces?

A. solid
B. liquid
C. gas
D. supercritical fluid

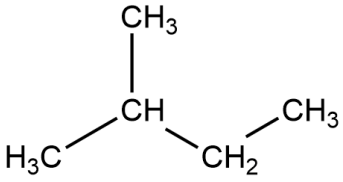
2. Based on the intermolecular forces, put the following molecules in order of **<u>decreasing</u>** boiling point.



pentane
(72.15 g/mol)



butanone
(72.11 g/mol)



isopentane
(72.15 g/mol)

A. isopentane > pentane > butanone
B. butanone > isopentane > pentane
C. pentane > butanone > isopentane
D. butanone > pentane > isopentane

3. Which molecule **<u>cannot</u>** hydrogen bond to another molecule of itself?

A. HF
B. NH_3
C. CH_4
D. CH_3OH

4. Which of the following statements is **<u>correct</u>** about surface tension?

A. A liquid comprised of polar molecules has larger surface tension than a liquid comprised of nonpolar molecules.
B. Surface tension is independent of temperature.
C. Surface tension does not depend on molecule size.
D. A liquid comprised of hydrogen-bonding molecules has smaller surface tension than a liquid comprised of molecules that cannot form hydrogen bonds.

5. A liquid is placed in a sealed flask. Which of the following explains the process of establishing the equilibrium vapor pressure?

A. The rate of evaporation and the rate of condensation both increase together until they no longer change.
B. The rate of evaporation begins high and decreases; the rate of condensation begins low and increases until it is the same as the rate of evaporation.
C. The rate of evaporation starts at zero and increases until it equals the rate of condensation.
D. The rate of condensation starts at zero and increases until it becomes constant and matches the constant rate of evaporation.

6. The heat (enthalpy) of vaporization (ΔH_{vap}) is _____. For a liquid sample with a fixed mass and surface area, _____.

A. temperature dependent; more molecules vaporize at lower temperature

B. temperature dependent; more molecules vaporize at higher temperature

C. temperature independent; more molecules vaporize at higher temperature

D. temperature independent; more molecules vaporize at lower temperature

7. The normal boiling point of diethyl ether is 34.6° C. What is the boiling point when the pressure is increased to 825 torr? ΔH_{vap} = 26.5 kJ/mol

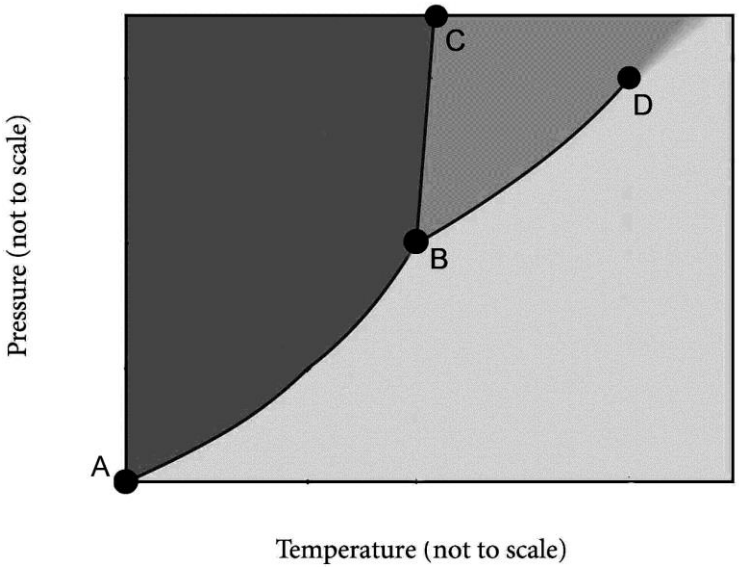
A. 24.1 °C

B. 28.9 °C

C. 37.1 °C

D. 46.8 °C

8. Which statement is true about this phase diagram?



A. Point A represents the temperature and pressure below which a supercritical fluid exists.

B. Point B represents the temperature and pressure at which gas, liquid and solid phases coexist.

C. The B-C line is the sublimation curve.

D. Point D represents the temperature and pressure below which a supercritical fluid can exist.

9. Sublimation is the phase change from _____; fusion is the phase change from _____.

A. solid to liquid; solid to gas
B. liquid to gas; liquid to solid
C. liquid to solid; gas to solid
D. solid to gas; solid to liquid

10. How much heat is **required** to melt 30.0 mg of acetone, $C_3H_6O(s)$, at its melting point of −94.8 °C? ΔH_{fus} = 5.69 kJ/mol; molar mass = 58.08 g/mol

A. 5.88 kJ
B. 0.278 kJ
C. 3.10×10^{-5} kJ
D. 2.94×10^{-3} kJ

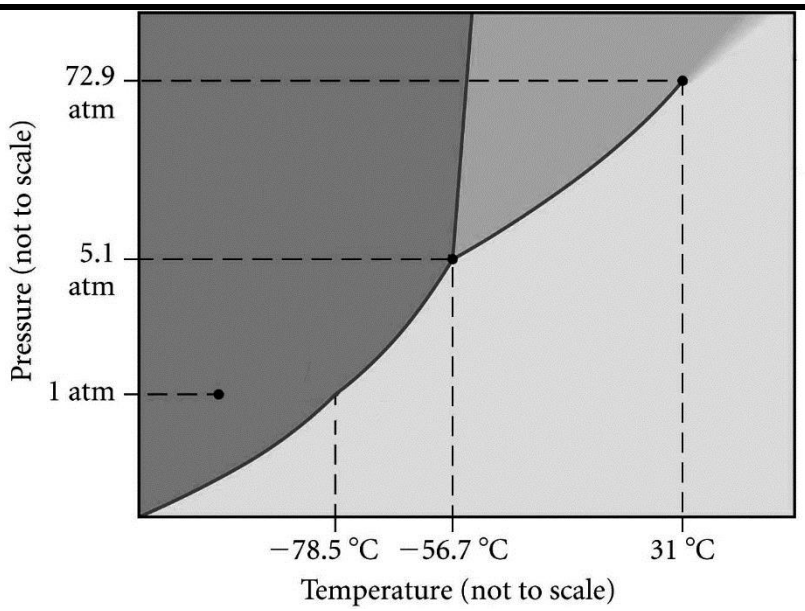
11. Water has the following properties:

molar mass = 18.02 g/mol
melting point = 0.00 °C
boiling point = 100.0 °C
ΔH_{fus} = 6.02 kJ/mol
ΔH_{vap} = 40.7 kJ/mol
C_s of $H_2O(s)$ = 2.09 J/g °C
C_s of $H_2O(l)$ = 4.18 J/g °C
C_s of $H_2O(g)$ = 2.01 J/g °C

How much energy is **required** to warm 60.1 g of $H_2O(l)$, initially at 80.0 °C, to $H_2O(g)$ at 140.0 °C?

A. 10.8 kJ
B. 42.7 kJ
C. 146 kJ
D. 175 kJ

12. Using the phase diagram shown for CO_2, what is the state of CO_2 at 30.0 °C and 74 atm?

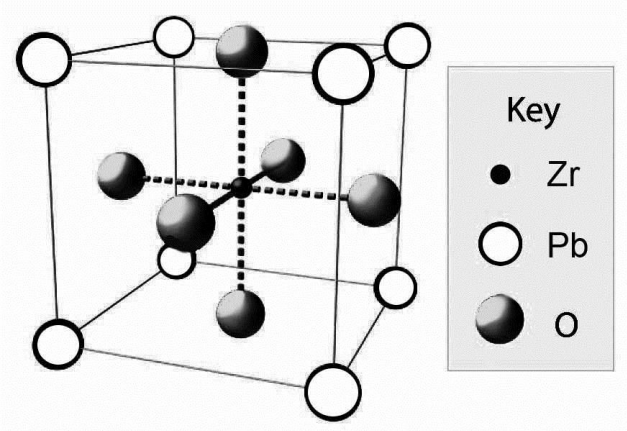


A. gas
C. solid
B. liquid
D. supercritical fluid

13. Which crystal structure is characterized by a coordination number of 6 and a packing efficiency of 52%?

A. simple cubic
C. face-centered cubic
B. body-centered cubic
D. cubic closest packing

14. Determine the ionic formula for lead zirconate, using the unit cell depicted on the right. The oxide ions (gray circles) are on each face, the lead ions (white circles) are on each cell corner, and the zirconium ion (smallest, black circle) is in the center.



A. $PbZrO_3$
C. Pb_4ZrO_3
B. $PbZr_2O_3$
D. Pb_8ZrO_6

15. A certain metal crystallizes in a face-center cube with edge length of 0.352 nm. The mass of a single atom of this metal is 9.75×10^{-23} g. Determine the density of the metal.

A. $2.22\ g/cm^3$

B. $8.94\ g/cm^3$

C. $8.99 \times 10^{-23}\ g/cm^3$

D. $1.31 \times 10^{3}\ g/cm^3$

16. Which of the following statements is **correct** about solids?

A. Ionic solids have high melting temperatures.

B. Network covalent solids have low melting temperatures.

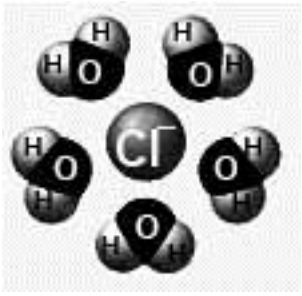
C. Metallic atomic solids all have low melting temperatures.

D. Nonbonding atomic solids have high melting temperatures.

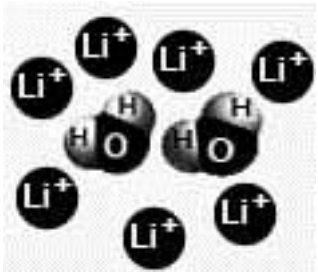
17. Which sketch is a reasonable representation of an ion-dipole interaction in an aqueous LiCl solution?

A.

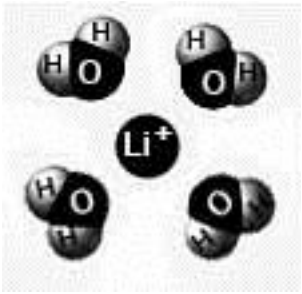
C.



B.



D.



18. The organic liquids nonane (C_9H_{20}) and benzene (C_6H_6)

A. are not miscible because there are no hydrogen bonds.

B. are not miscible because they are not identical, so the intermolecular interactions in the liquids are not of similar type and magnitude.

C. are miscible because they are both polar molecules.

D. are miscible because intermolecular interactions in the liquids are of similar type and magnitude.

19. In an **saturated** solution of KBr in water,

A. dissolved KBr is precipitating more rapidly than solid KBr is dissolving.

B. solid KBr is dissolving more rapidly than dissolved KBr is precipitating.

C. KBr is precipitating at the same rate that solid KBr is dissolving.

D. more KBr is dissolved than is predicted by the maximum equilibrium concentration.

20. Which of the following is **true** about a supersaturated solution of sodium acetate (solute) in water (solvent)?

A. The solute and solvent in a supersaturated solution are in dynamic equilibrium.

B. A portion of the solid solute is present at the bottom of the flask.

C. Adding a crystal of sodium acetate will lead to crystallization of the excess solute.

D. Less sodium acetate is dissolved than is predicted by the maximum equilibrium concentration.

21. A can of soda is at a carbon dioxide pressure of 4.7 atm at 10 °C. What is the concentration of carbon dioxide in the soda? $k_H = 3.4 \times 10^{-2}$ M/atm at 10 °C for CO_2

A. 0.12 M

B. 0.16 M

C. 0.58 M

D. 0.99 M

22. A solution is prepared by mixing 2.50 g NaOH with 450. g of water at 25.0 °C. What is the **molality** of NaOH? The density of water is 1.00 g/mL.

A. 72.0 *m*

B. 45.0 *m*

C. 0.139 *m*

D. 2.78×10^{-4} *m*

23. What is the ppm concentration when 9.30 mg $CuCl_2$ is dissolved in 750. mL of water? Water has a density of 1.00 g/mL.

A. 0.0161 ppm
C. 7.97 ppm
B. 2.15 ppm
D. 12.4 ppm

24. Which statement is **true** about concentration units?

A. Micrograms of solute per liter of solvent defines ppm by mass.
B. Molarity is defined as moles of solution per gram of solute.
C. Molality is defined as grams of solute per kilogram of solvent.
D. The molarity of a solution depends on temperature.

25. The mole percent of an aqueous solution of $KClO_3$ is 2.1% at 30 °C. Determine the **molality** of this solution.

A. 9.3 *m*
C. 0.46 *m*
B. 1.2 *m*
D. 2.1×10^{-2} *m*

26. The experimentally measured Van't Hoff factor for $MgSO_4$ in water is 1.30 at 0.050 *m*. Which statement is **true**?

A. The experimental Van't Hoff factor is less than the predicted value because there are more magnesium ions than sulfate ions in solution.
B. The experimental Van't Hoff factor is greater than the predicted value because the salt dissociates into magnesium ions and sulfate ions in water.
C. The experimental Van't Hoff factor is less than the predicted value because some magnesium ions and sulfate ions exist as ion pairs in water.
D. The Van't Hoff factor approaches 3.00 as the solution is made more dilute.

27. Determine the **vapor pressure** of a solution at 55 °C that contains 144 g of glycerol (a nonvolatile nonelectrolyte, 92.09 g/mol) in 225 mL of water. The vapor pressure of pure water at 55.0 °C is 118 torr. Assume the density of water to be 1.00 g/mL at 55.0 °C.

A. 91.3 torr
C. 113 torr
B. 105 torr
D. 123 torr

28. Calculate the **boiling point** of a solution containing 17.0 g of naphthalene (nonvolatile, $C_{10}H_8$, molar mass = 128.18 g/mol) in 111.0 mL of benzene (C_6H_6). Benzene has density = 0.877 g/cm^3, boiling point = 80.1 °C and K_b = 2.53 °C/*m*.

A. 83.6 °C
C. 76.4 °C
B. 80.1 °C
D. 73.1 °C

29. A solution is prepared by dissolving 8.70 mg of an unknown nonelectrolyte in enough water to make 1.00 mL of solution. The osmotic pressure of this solution is 368 torr at 25.0 °C. What is the **molar mass** of the unknown solute?

A. 16.1 g/mol
C. 439 g/mol
B. 80.8 g/mol
D. 3.14×10^3 g/mol

30. Rank the aqueous solutions in order of **increasing** boiling point.

A. 1.0 M sucrose < 1.0 M KCl < 2.0 M KCl
B. 1.0 M sucrose < 2.0 M KCl < 1.0 M KCl
C. 2.0 M KCl < 1.0 M KCl < 1.0 M sucrose
D. 2.0 M KCl = 1.0 M KCl = 1.0 M sucrose

Answer Key:

1. A
2. D
3. C
4. A
5. D
6. B
7. C
8. B
9. D
10. D
11. C
12. B
13. A
14. A
15. B
16. A
17. D
18. D
19. C
20. C
21. B
22. C
23. D
24. D
25. B
26. C
27. B
28. A
29. C
30. A