A.P. Chemistry Practice Test: Ch. 10 – Liquids and Solids

Name_____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Crystalline solids _____.
   A) exist only at very low temperatures
   B) have their particles arranged randomly
   C) have highly ordered structures
   D) are usually very soft
   E) exist only at high temperatures

2) In liquids, the attractive intermolecular forces are _____.
   A) strong enough to hold molecules relatively close together but <u>not</u> strong enough to keep molecules from moving past each other
   B) not strong enough to keep molecules from moving past each other
   C) very weak compared with kinetic energies of the molecules
   D) strong enough to hold molecules relatively close together
   E) strong enough to keep the molecules confined to vibrating about their fixed lattice points

3) Based on molecular mass and dipole moment of the five compounds in the table below, which should have the highest boiling point?

Substance	Molecular Mass (amu)	Dipole Moment (D)
Propane, $CH_3CH_2CH_3$	44	0.1
Dimethylether, CH_3OCH_3	46	1.3
Methylchloride, CH_3Cl	50	1.9
Acetaldehyde, CH_3CHO	44	2.7
Acetonitrile, CH_3CN	41	3.9

   A) CH_3OCH_3
   B) CH_3CN
   C) CH_3CHO
   D) CH_3Cl
   E) $CH_3CH_2CH_3$

4) The intermolecular force(s) responsible for the fact that CH_4 has the lowest boiling point in the set CH_4, SiH_4, GeH_4, SnH_4 is/are _____.
   A) mainly hydrogen bonding but also dipole–dipole interactions
   B) hydrogen bonding
   C) mainly London–dispersion forces but also dipole–dipole interactions
   D) dipole–dipole interactions
   E) London dispersion forces

5) Elemental iodine (I_2) is a solid at room temperature. What is the major attractive force that exists among different I_2 molecules in the solid?

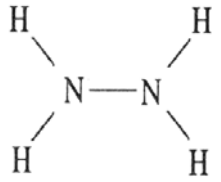
A) dipole–dipole rejections
B) covalent–ionic interactions
C) London dispersion forces
D) dipole–dipole attractions
E) ionic–dipole interactions

6) Of the following substances, only _____ has London dispersion forces as its only intermolecular force.

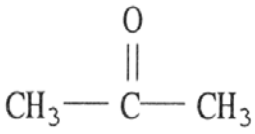
A) CH_3OH B) HCl C) H_2S D) CH_4 E) NH_3

7) Which one of the following substances will not have hydrogen bonding as one of its intermolecular forces?

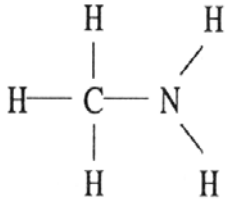
A)



B)

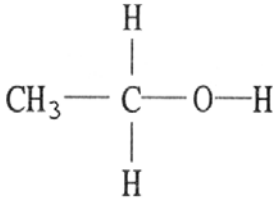


C)



D)

E)



ESSAY. Write your answer in the space provided or on a separate sheet of paper.

8) The boiling point of carbon tetrachloride (CCl_4) is higher than that of chloroform ($CHCl_3$). Since chloroform is polar and carbon tetrachloride is not, consideration of dipole–dipole forces would predict that chloroform would have the higher boiling point. How can we account for the observed order of the boiling points?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

9) The predominant intermolecular force in $(CH_3)_2NH$ is _____.
   A) ion–dipole forces
   B) hydrogen bonding
   C) ionic bonding
   D) dipole–dipole forces
   E) London dispersion forces

10) Of the following substances, _____ has the highest boiling point.
   A) H_2O B) CO_2 C) NH_3 D) CH_4 E) Kr

11) The property responsible for the "beading up" of water is _____.
   A) vapor pressure
   B) density
   C) hydrogen bonding
   D) surface tension
   E) viscosity

12) The direct conversion of a solid to a gas is called _____.
   A) fusion B) sublimation C) condensation D) boiling E) vaporization

13) Of the following, _____ is an exothermic process.
   A) freezing
   B) boiling
   C) subliming
   D) melting
   E) All of the above are exothermic.

14) Large intermolecular forces in a substance are manifested by _____.
   A) high critical temperatures and pressures
   B) high boiling point
   C) low vapor pressure
   D) high heats of fusion and vaporization
   E) all of the above

15) In general, the vapor pressure of a substance increases as _____ increases.
   A) molecular weight
   B) viscosity
   C) hydrogen bonding
   D) surface tension
   E) temperature

16) The vapor pressure of any substance at its normal boiling point is

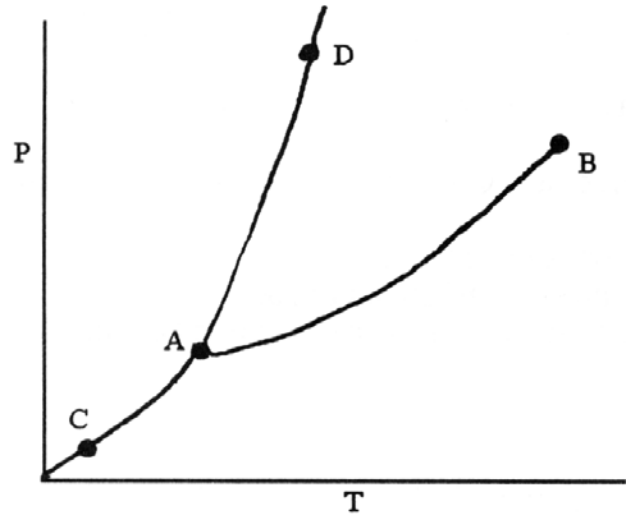
A) 1 atm

B) equal to atmospheric pressure

C) 1 torr

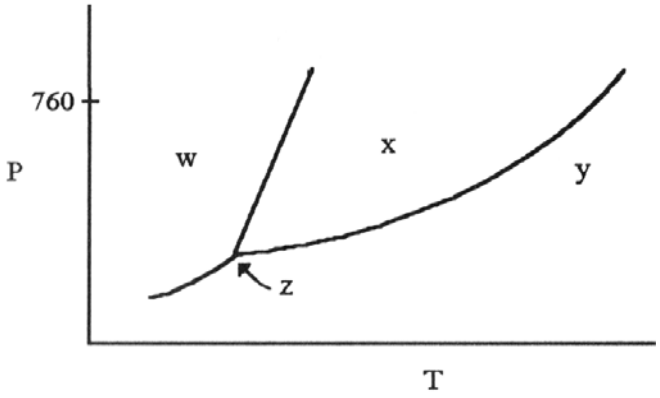
D) equal to the vapor pressure of water

E) 1 Pa



17) On the phase diagram above, segment _____ corresponds to the conditions of temperature and pressure under which the solid and the gas of the substance are in equilibrium.

A) CD B) AB C) AD D) BC E) AC



18) The phase diagram of a substance is given above. The region that corresponds to the solid phase is _____.

A) w B) x C) y D) z E) x and y

19) On a phase diagram, the critical temperature is _____.

A) the temperature required to melt a solid

B) the temperature at which all three states are in equilibrium

C) the temperature above which a gas cannot be liquefied

D) the temperature below which a gas cannot be liquefied

E) the temperature required to cause sublimation of a solid

20) When the phase diagram for a substance has a solid–liquid phase boundary line that has a negative slope (leans to the left), the substance _____.

A) sublimes rather than melts under ordinary conditions

B) melts rather than sublimes under ordinary conditions

C) cannot be liquefied above its triple point

D) can go from solid to liquid, within a small temperature range, via the application of pressure

E) cannot go from solid to liquid by application of pressure at any temperature

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

21) Explain the difference between an amorphous and a crystalline solid on the microscopic level.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

22) The predominant intermolecular force in $CaBr_2$ is _____.

A) hydrogen bonding

B) London–dispersion forces

C) ion–dipole forces

D) dipole–dipole forces

E) ionic bonding

23) The enthalpy change for converting 10.0 g of water at 25.0°C to steam at 135.0°C is _____ kJ. The specific heats of ice, water, and steam are 2.09 J/g–K, 4.18 J/g–K, and 1.84 J/g–K, respectively. For H_2O, $\triangle H_{fus}$ = 6.01 kJ/mol, and $\triangle H_{vap}$ = 40.67 kJ/mol

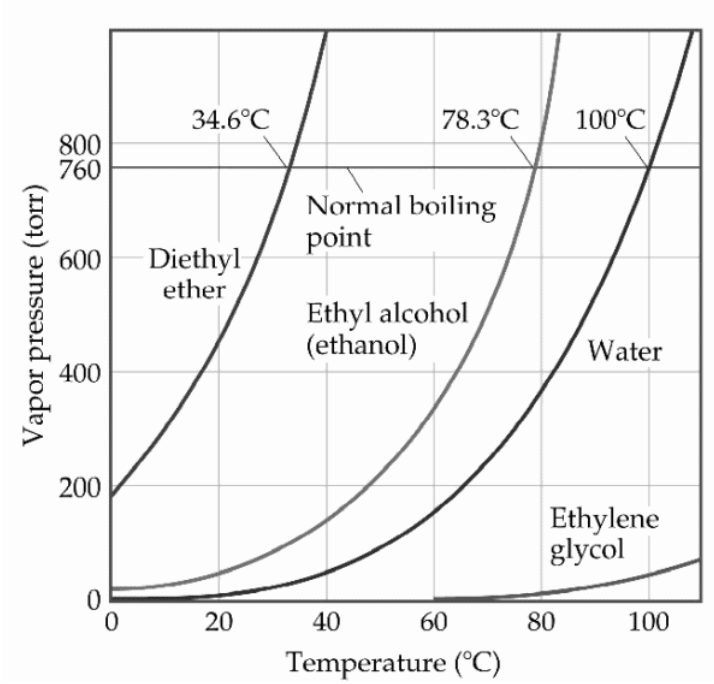
A) 473.6 B) 26.35 C) 47.36 D) 4322 E) 44.95

24) The enthalpy change for converting 1.00 mol of ice at –50.0°C to water at 70.0°C is _____ kJ. The specific heats of ice, water, and steam are 2.09 J/g–K, 4.18 J/g–K, and 1.84 J/g–K, respectively. For H_2O, $\triangle H_{fus}$ = 6.01 kJ/mol, and $\triangle H_{vap}$ = 40.67 kJ/mol

A) 6.41 B) 9.40 C) 13.16 D) 7154 E) 12.28

25) The fluorocarbon $C_2Cl_3F_3$ has a normal boiling point of 47.6°C. The specific heats of $C_2Cl_3F_3$ (l) and $C_2Cl_3F_3$(g) are 0.91 J/g–K and 0.67 J/g–K, respectively. The heat of vaporization of the compound is 27.49 kJ/mol. The heat required to convert 50.0 g of the compound from the liquid at 5.0°C to the gas at 80.0°C is _____ kJ.

A) 1454 B) 30.51 C) 8.19 D) 10.36 E) 3031



26) Based on the figure above, the boiling point of ethyl alcohol under an external pressure of 0.0724 atm is _____°C.

A) 60 B) 20 C) 70 D) 80 E) 40

Answer Key
Testname: CH_10_PRACTICE_TEST_LIQUIDS_SOLIDS.TST

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) C
ID: chem9b 2.1-1

2) A
ID: chem9b 2.1-2

3) B
ID: chem9b 2.1-9

4) E
ID: chem9b 2.1-23

5) C
ID: chem9b 2.1-24

6) D
ID: chem9b 2.1-25

7) B
ID: chem9b 2.1-29

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

8) Carbon tetrachloride is significantly larger than chloroform, and larger molecules tend to have greater polarizabilities because they have a greater number of electrons and their electrons are further from the nuclei. Thus, London dispersion forces between carbon tetrachloride molecules raises its boiling point above that of chloroform even though chloroform experiences both London dispersion and dipole–dipole forces.
ID: chem9b 2.1-32

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

9) B
ID: chem9b 2.1-33

10) A
ID: chem9b 2.1-34

11) D
ID: chem9b 2.1-45

12) B
ID: chem9b 2.1-46

13) A
ID: chem9b 2.1-48

14) E
ID: chem9b 2.1-56

15) E
ID: chem9b 2.1-67

16) A
ID: chem9b 2.1-68

17) E
ID: chem9b 2.1-73

18) A
ID: chem9b 2.1-76

19) C
ID: chem9b 2.1–83

20) D
ID: chem9b 2.1–85

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

21) Amorphous solids lack long–range order that is found in crystalline solids.
ID: chem9b 2.1–86

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

22) E
ID: chem9b 2.1–97

23) B
ID: chem9b 2.2–2

24) C
ID: chem9b 2.2–3

25) D
ID: chem9b 2.2–5

26) B
ID: chem9b 2.2–9

ANSWER KEY: PRACTICE TEST, CH. 10 – LIQUIDS AND SOLIDS

1. Answer is (c). Review the section of the text that talks about structure of solids, particularly the difference between crystalline and amorphous solids.

2. Answer is (a). Review the section of the text about the difference between the structure and strength of intermolecular forces in liquids vs solids.

3. Molecular mass should be irrelevant here, as far as I know. * Polar substances, all things being equal, will usually have stronger intermolecular forces (dipole-dipole interactions) than nonpolar substances (which are held together by strength of London dispersion forces). The molecular mass is about the same for these substances, so the most polar substance should have the strongest intermolecular attractions, and should therefore have the highest boiling point.

   Based on the information available, the answer should be acetonitrile, choice (b). Note; dipole moment is measured in units called **debyes**, the symbol for which is "D." So, acetonitrile is the most polar molecule in this group because it has the greatest dipole moment. Its dipole moment is 3.9 D.

   * (However, the higher the molecular should indicate that a substance has more electrons. Number of electrons is important for determining the strength of London dispersion forces.)

4. The answer is (e), London dispersion forces. The members of this analogous series have this in common:
   - they cannot be bound by H- bonding
   - they cannot be attracted by dipole-dipole interactions
   - but they **can** be attracted by London dispersion forces.

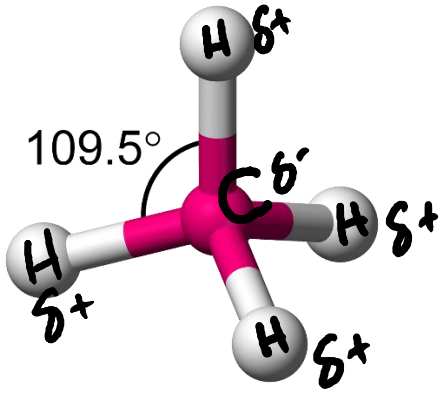
   So, this is an apples-to-apples comparison of substances whose main intermolecular force of attraction is London dispersion forces. These are all nonpolar molecules.

   It now remains to determine which substance has the strongest London dispersion forces. The answer is SnH_4, because it has more electrons. CH_4 would have the weakest London dispersion forces, because it has the fewest electrons.

   London dispersion forces are important intermolecular forces for nonpolar substances. London dispersion forces are caused by the temporary, uneven distribution of electrons within a molecule. The more electrons there are, the more important the effect is when the electrons become unevenly distributed. Molecules with more electrons are more polarizable, and molecules with fewer electrons are less polarizable.

5. I_2 is nonpolar. What, then, could cause a molecule of I_2 to be attracted to another molecule of I_2? Obviously, molecules of I_2 are indeed very attracted to other molecules of I_2, or else the substance wouldn't be a solid. Answer: for nonpolar substances, the important intermolecular force is London dispersion forces, choice (c).

6. Since London dispersion forces are the important intermolecular force for nonpolar substances, pick the molecule which is nonpolar. CH_4 is the least polar of those substances. In fact, it is nonpolar, because even though the C-H bond is weakly polar, there are no distinct, separable positive and negative sides to the molecule. See diagram below.

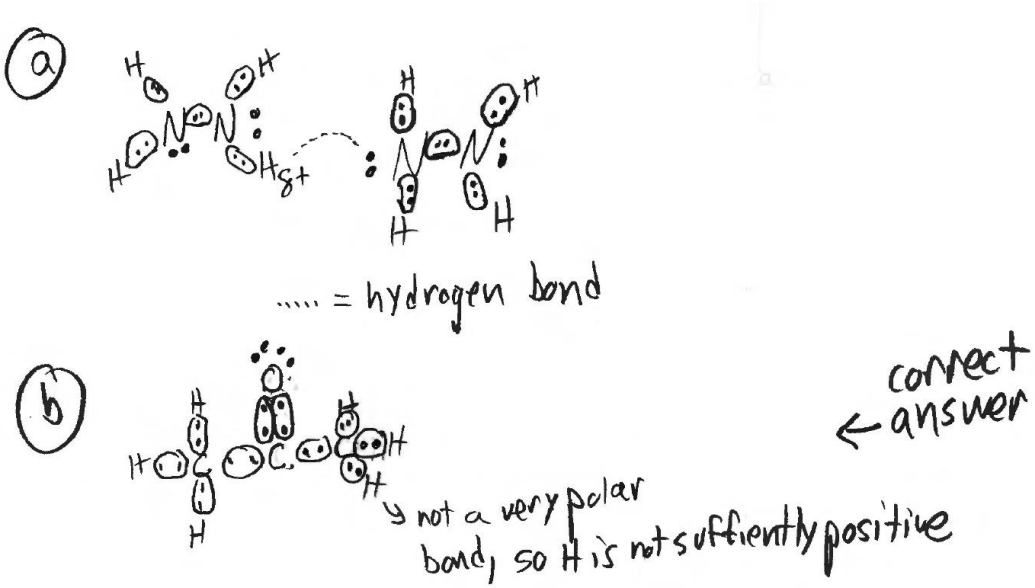


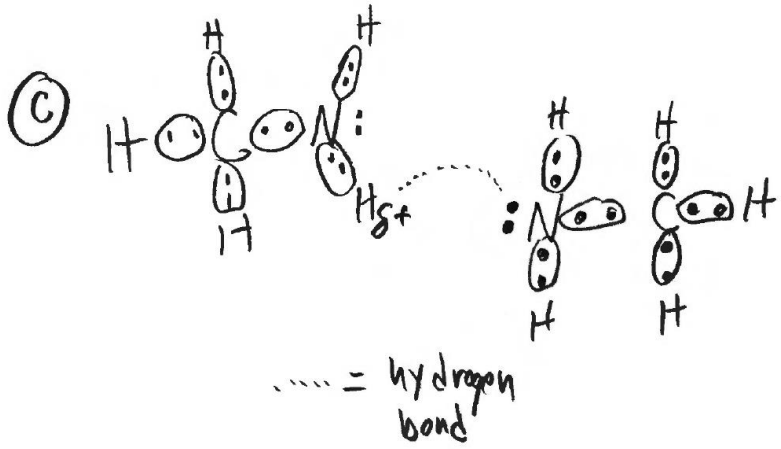
Source: ttps://upload.wikimedia.org/wikipedia/commons/e/e8/Tetrahedral-angle-3D-balls.png

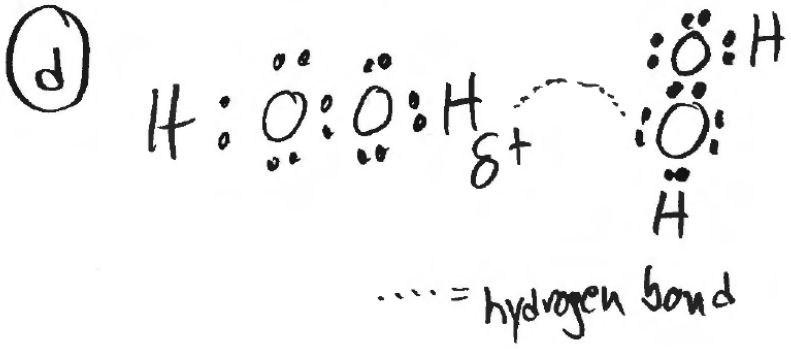
7. In order for hydrogen bonds to form between two molecules, these three conditions must be met:
   - Hydrogen must be present
   - The hydrogen must be part of a very polar bond, which in practice means that it must be bonded to N, O or F
   - There must be unshared pairs on some nearby molecule to which the partially positive H can be attracted.

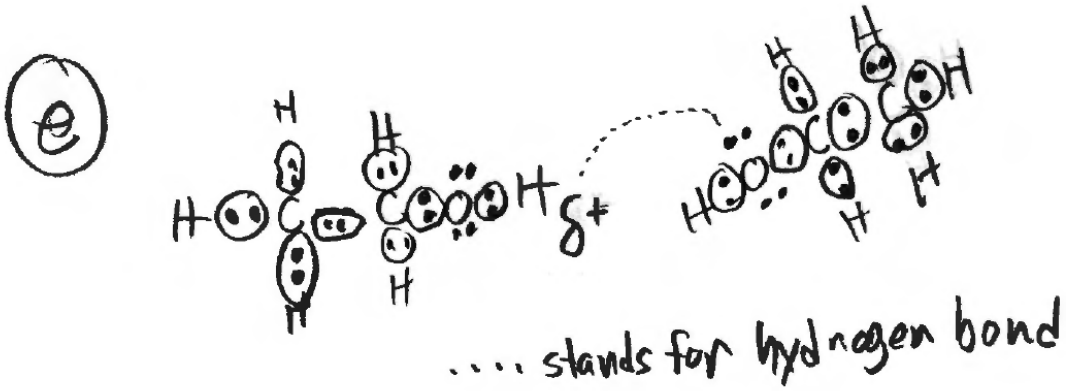
   Choice (b) is the only substance that cannot form hydrogen bonds. It does not have the very polar covalently bonded hydrogens which are necessary. If the hydrogen atoms are not sufficiently "electron-starved", then they will not be attracted to the unshared pairs of electrons on nearby molecules.

   *NOTE: it is necessary to actually write out the dot structures - as opposed to just looking at the structural formulas given in the problem - of each compound to see the unshared pairs. Therefore, it might be necessary to write the dot structures to get the problem correct. I needed to write them out, though you may have a different way of solving this problem.









8. Ordinarily, and all things being equal, one would expect the following order of intermolecular forces:

   H-bonding is stronger than **dipole-dipole interactions**, and dipole-dipole interactions are stronger than **London dispersion forces**

   H-bonding > dipole-dipole interactions > London dispersion forces

However, this problem states that the boiling point of the polar substance, $CHCl_3$ is **lower** than that of the nonpolar substance, CCl_4.

This might not have been expected, but it is true. How could this be rationalized? Well, it must mean that the London dispersion forces among CCl_4 molecules is greater than the dipole-dipole interactions among $CHCl_3$ molecules. The permanent dipole of the chloroform molecules must not cause as great an effect as the intermolecular attraction caused by the LDF among the carbon tetrachloride molecules. Carbon tetrachloride has a total of 74 electrons which could possibly be temporarily unevenly distributed. $CHCl_3$, however, only has 58 electrons. Apparently, the greater number of electrons in in CCl_4 has a bigger effect on boiling point than the permanent dipole of the $CHCl_3$ molecule.

The hierarchy of intermolecular force strengths given above is only the usual and expected order of forces, all things being equal. Note that water, for instance, is a very good example of H-bonding, but it is still a liquid at room temperature. Elemental diatomic iodine (I_2), however, even though only held to other iodine molecules through London dispersion forces, is a solid at room temperature, indicating that it has stronger intermolecular forces than water does.

9. The answer is (b), because it meets all of the criteria for being able to H-bond.

10. The answer is (a). There are several possible ways to answer this question. Here are two:
    - One could recognize that all of those substances are gases at room temperature and standard pressure except for water. Therefore, water must have the strongest intermolecular forces, and should have the highest boiling point. CO_2 is a gas that we expel as we breathe. NH_3, ammonia, is the gas dissolved in Windex ® and ammonia cleaning solutions. CH_4 is called natural gas and is burned in Bunsen burners. Krypton, a member of the noble gas family, is a gas.
    - Alternatively, only water and ammonia exhibit hydrogen bonding. Water, though, has a more polar bond (H-O vs H-N) and has **two** unshared pairs available for hydrogen bonding. Therefore, water should have the strongest intermolecular forces, and should have the highest boiling point.

11. Correct answer: (d). Review the section of the text that discusses capillary action, surface tension, adhesion, and cohesion.

12. Correct answer: (b). Be familiar with the conversion of dry ice, which is CO_2 (s), to CO_2 (g). Know the names of all phase changes (solid to liquid, liquid to gas, etc). Know whether energy (heat) is released or absorbed by the system for all phase changes.

13. The freezing of a substance such as water requires that energy (heat) be released from the system to the surroundings. If heat were absorbed by water, on the other hand, then the water would not freeze. When a process releases heat, that process is called exothermic. All of the other choices (b through d) are endothermic.

14. We covered (b), (c), and (d), so the answer is (e). All of those conditions require the particles of a substance to be strongly attracted to one another.

15. (e) was what I had in mind. I didn't give much thought to the others. Note: you could fake this answer by looking at the graph for question #26 in this practice test. It clearly shows that for 4 different liquids, the vapor pressure increases as the temperature increases.

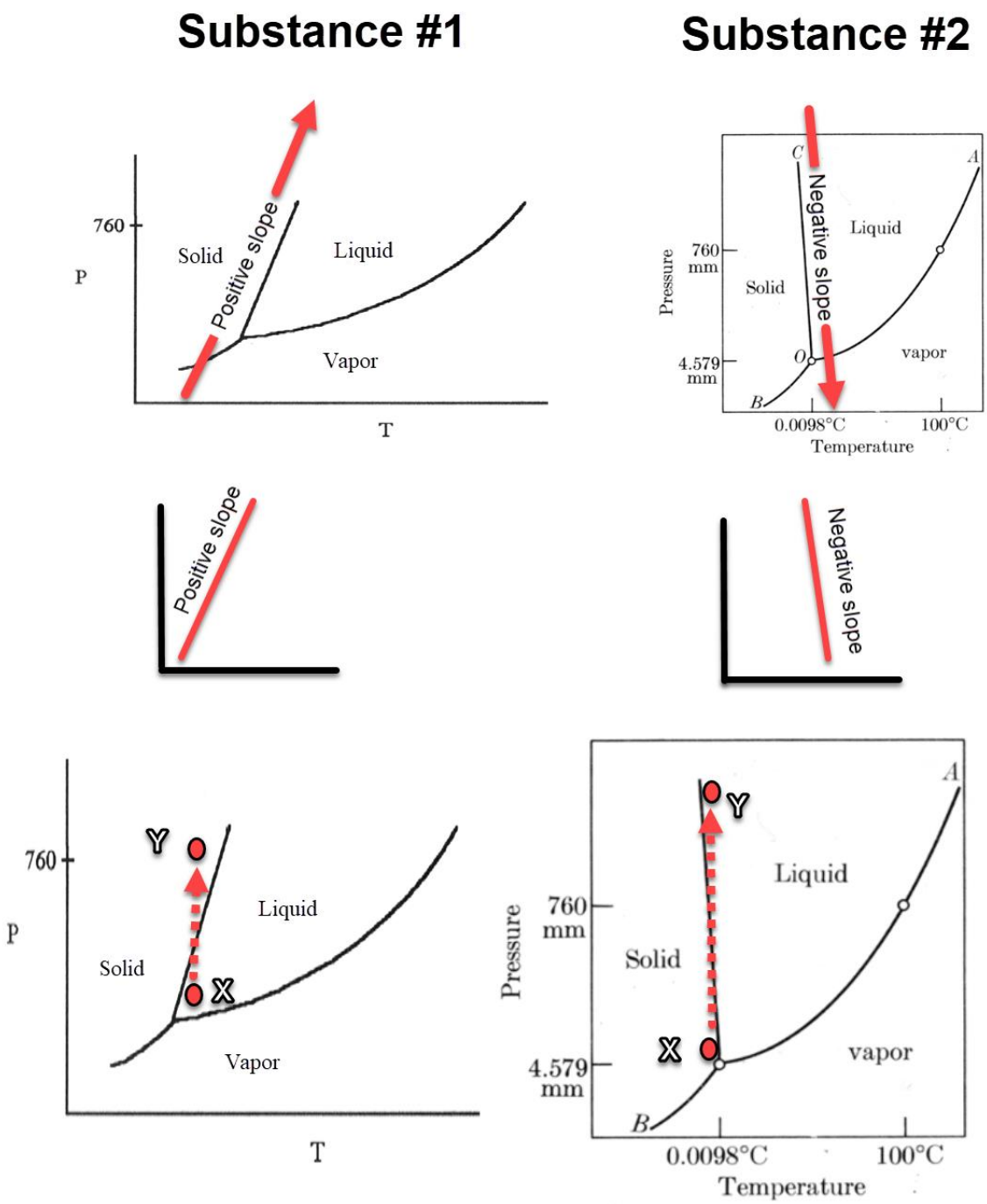
16. (b) is just the definition of boiling point.

17. Segment AC [answer choice (e)] is correct. Be sure to memorize the regions of the phase diagram (solid, liquid gas).

18. Choice (a), region w.

19. Answer is (d). Memorize triple point and critical point.

20. Answer to this question is best shown by a large diagram. See below.



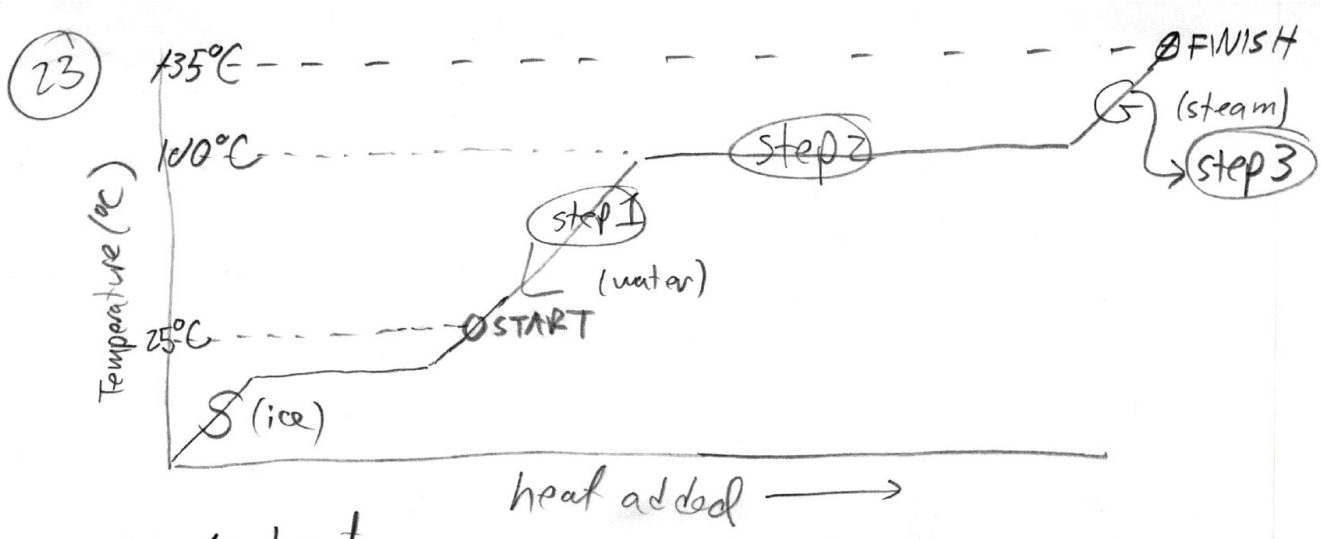
Problem #20: **Substance #1** has a **positive** slope along its solid-liquid phase boundary. As the pressure is increased at constant temperature (from point X to point Y), it is possible to turn the substance from a liquid to a solid (but this only works for a narrow range of temperatures). **Substance #2** has a **negative** slope along its solid-liquid phase boundary. As the pressure is increased at constant temperature (from point X to point Y), it is possible to turn the substance from a solid to a liquid (but this only works for a narrow range of temperatures). Thus, the answer is choice (d). Substance #2 is H_2O, and it is unusual in that when its liquid freezes, it expands. When its solid melts, it contracts.

ANSWER KEY: PRACTICE TEST, CH. 10 – LIQUIDS AND SOLIDS

21. Amorphous: disordered structure. Crystalline: regular, repeating array of ions or atoms.

22. Metal & nonmetal = ionic. Because ionic substances don't form discreet molecules, I would argue that "intermolecular" is a misleading term here. There are no molecules. There are a bunch of ions linked together in a negative-positive-negative, etc. matrix. Anyway, $CaBr_2$ is held together by ionic bonds.

23. See below.



step 1: heat water from 25°C to 100°C

$q = mC\Delta T$

$= (10.0\,g)\left(\frac{4.18\,J}{g°C}\right)(75.0°C) = 3135\,J$ → this gives the same answers as when you use Kelvins

step 2: vaporize 10.0 g of water

$10.0\,g \times \frac{1\,mol}{18.02\,g} \times \frac{40.67\,kJ}{1\,mol} = 22.569\,kJ$

$H + H + O = H_2O$

$1.01 + 1.01 + 16.00 = 18.02$

step 3: heat 100°C steam to 135°C steam

$q = mC\Delta T$

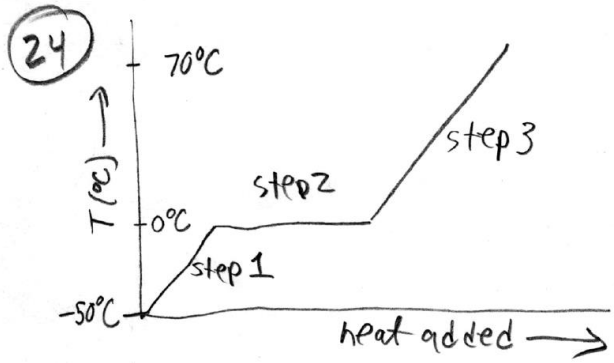
$= (10.0\,g)\left(\frac{1.84\,J}{g°C}\right)(35.0°C) = 644\,J$

TOTAL = step 1 + step 2 + step 3

$= 3135\,J + 22569\,J + 644\,J = 26348\,J$

$= 26.3\,kJ$ (B)

24. See below.



step 1 :

$q = mC\Delta T$

$= (18.02\,g)\left(\frac{2.09\,J}{g^{\circ}C}\right)(50.0^{\circ}C)$ } heating ice from $-50^{\circ}C$ to $0^{\circ}C$

$= 1883.09\,J$

$1\,mol\,H_2O \times \frac{18.02\,g}{1\,mol\,H_2O} = \underline{18.02\,g\,H_2O}$

step 2 : $1.00\,mol \times \frac{6.01\,kJ}{1\,mol} = 6.01\,kJ$ } melting $0^{\circ}C$ ice to make $0^{\circ}C$ water

step 3 : $q = mC\Delta T$

$= (18.02\,g)\left(\frac{4.18\,J}{g^{\circ}C}\right)(70.0^{\circ}C)$ } heating $0^{\circ}C$ water to $70^{\circ}C$.

$= 5272.652\,J$

total = step 1 + step 2 + step 3

$= 1883\,J + 6010\,J + 5272\,J$

$= 13165.742\,J$

$= 13.17\,kJ$ (C)

#25 and #26: See below.

(25) step 1: heat liquid from 5.0°C → 47.6°C
step 2: vaporize liquid at 47.6°C
step 3: heat vapor from 47.6°C to 80°C

step 1:
$q = mC\Delta T$
$= (50.0\,g)\left(\frac{0.91\,J}{g°C}\right)(42.6°C)$
$= 1938.3\,J$

$47.6 - 5.0 = 42.6$

step 2:
$50.0\,g \times \frac{1\,mol}{187.37\,g} \times \frac{27.49\,kJ}{1\,mol}$
$= 7.3357\,kJ$

$C \times 2 = 12.01 \times 2 = 24.02$
$Cl \times 3 = 35.45 \times 3 = 106.35$
$F \times 3 = 19.0 \times 3 = 57.0$
$187.37\,g / 1\,mol$

step 3:
$q = mC\Delta T$
$= (50.0\,g)\left(\frac{0.67\,J}{g°C}\right)(32.4°C)$
$= 1085.4\,J$

$80.0 - 47.6 = 32.4$

total = step 1 + step 2 + step 3
$= 1938.8 + 7335.7 + 1085.4$
$= 10359.4\,J = 10.4\,kJ$ (D)

(26) when P_{atm} = V.P. of liquid, boiling occurs. Notice that the chart is in torr.
$P_{atm} = 0.0724\,atm \times \frac{760\,torr}{1\,atm} = 55.0\,torr$
Eyeballing that graph, I estimate that ethyl alcohol will have a vapor pressure of 55.0 torr at about 20°C, (B)