AP Chem - Unit 7 Exam - Key

1. ANS: C
It's an open container, so you can't change the pressure easily. Changing the volume of the open container or the amount of liquid in the open container will not affect the boiling point, it will just affect the time it takes to boil.

Changing altitude **will** affect the boiling point. A substance boils when its vapor pressure is equal to the atmospheric pressure. Higher altitudes have lower atmospheric pressures, so as heat energy is added to the system, the vapor pressure of the pure liquid will equal the atmospheric pressure at a lower temperature.

DIF: Medium OBJ: 2.4 NAT: 1.4 | 6.4 TOP: States of Matter
KEY: vapor pressure | boiling NOT: 61% answered correctly

2. ANS: D
$I_2(s) \rightarrow I_2(g)$--phase change; energy added to overcome dispersion IMFs in molecular solid

$CO_2(s) \rightarrow CO_2(g)$--phase change; solid carbon dioxide is not a network covalent solid nor an ionic crystal, energy added to overcome dispersion IMFs in a molecular solid

$NaCl(s) \rightarrow NaCl(l)$--phase change; energy added to overcome lattice energy and melt ionic crystal

C(diamond) $\rightarrow$ C(*g*)--phase change; BUT diamond and graphite are network covalent solids, meaning *four* covalent bonds exist between the carbons of diamond, that's why it is so hard!

DIF: Medium OBJ: 2.16 NAT: 6.2 TOP: States of Matter
KEY: solids | network covalent | molecular solid | ionic solid | metallic solid
NOT: 54% answered correctly

3. ANS: A
Methane obeys the octet rule, has tetrahedral geometry with 4 equivalent C–H bonds nonpolar covalent bonds having an electronegativity difference of 0.4 on the Pauling scale. Therefore, the only way methane molecules attract each other is with London dispersion forces (LDFs). The more electrons present in a nonpolar molecule the more polarizable it is, the stronger the LDFs. Also note that if the question had substituted a F for all 4 H's, the molecule would still be nonpolar (but have more electrons!), thus still only LDFs. Also note that *all* molecules exhibit LDFs as one of their intermolecular forces.

DIF: Medium OBJ: 2.16 NAT: 6.2 TOP: IMFs
KEY: polar molecules | Lewis dot structures | IMFs NOT: 46% answered correctly

4. ANS: C
Boiling point is defined as the temperature at which the vapor pressure of the liquid becomes equal to the atmospheric pressure on the surface of the liquid. Also note that the "normal" boiling point defines "atmospheric pressure on the surface of the liquid" to be exactly 1 atm.

DIF: Medium OBJ: 2.16 NAT: 6.2 TOP: States of Matter
KEY: boiling point | vapor pressure | colligative properties NOT: 52% answered correctly

5. ANS: A
Everything is a gas except bromine, so that's your winner! But *why, oh why,* is Br a liquid at room temperature? Shouldn't it also be a gas...what's the scoop with I solid?

Bromine molecules "stick to each other" (because they are more attracted to each other) even though they are very, very nonpolar molecules with only London dispersion forces. It is also important to note that bromine molecules have the most electrons, and are thus more polarizable so their IMFs are stronger than the others in the lists. Go on to I_2 and it has more electrons still, thus is even more polarizable and is a solid at room temperature, but sublimes!

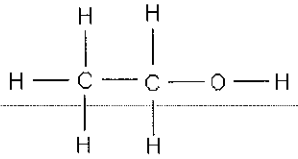
DIF: Hard OBJ: 2.32 NAT: 1.1 | 6.2 | 7.1 TOP: IMFs
KEY: London dispersion forces | melting point NOT: 33% answered correctly

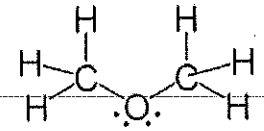
AP Chem - Unit 7 Exam - Key

6. ANS: D
The pure hydrocarbon butane *X*, is the least polar, thus has the lowest solubility in water. The presence of an –OH group, specifically the 2 unshared pairs of electrons on the oxygen of butanol *Y*, makes it more soluble than butane, but less soluble than the 1,3-propanediol *Z*, that contains two –OH groups. Aren't you glad you don't have to name all of them?

DIF: Hard OBJ: 2.16 NAT: 6.2 TOP: IMFs
KEY: hydrogen bonding | physical properties |organic NOT: 39% answered correctly

7 ANS: B
Structural isomers have the same number of atoms, but a different arrangement of those atoms. The VP, BP, MP and ΔH_{vap} all depend on IMFs. Examine the structure of the two isomers: ethanol (2 lone pairs missing from O in the diagram) vs. dimethylether



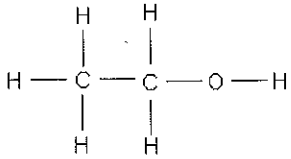


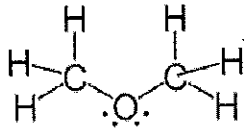
Since ethanol has *a* hydrogen atom (as opposed to all of them!) bound to a "highly electronegative" atom (F, N or O--in this case O), it can exhibit hydrogen bonding which is a special case of dipole-dipole IMFs. Dimethylether has no hydrogens bound to a highly electronegative atom, thus it cannot hydrogen bond and its only IMF is the much weaker induced dipole-induced dipole force (also called London dispersion forces). Dispersion forces are much weaker, so dimethylether has a much lower VP, BP, MP and ΔH_{vap} since less energy is required to separate molecules since they are less attracted to each other than those of ethanol.

DIF: Easy OBJ: 2.13 NAT: 1.4 TOP: IMFs
KEY: dipole-dipole | hydrogen bonding | isomers | organic NOT: 77% answered correctly

8 ANS: A
Structural isomers have the same number of atoms, but a different arrangement of those atoms. A gas's density at STP is calculated using this formula : $density = \dfrac{MM}{22.4\,^{L}/_{mol}}$ and is independent of the arrangement of the atoms.

The VP, BP, MP and ΔH_{vap} all depend on IMFs. Examine the structure of the two isomers: ethanol (2 lone pairs missing from O in the diagram) vs. dimethylether



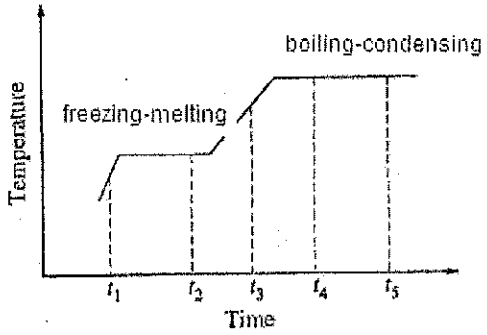


Since ethanol has *a* hydrogen atom (as opposed to all of them!) bound to a "highly electronegative" atom (F, N or O--in this case O), it can exhibit hydrogen bonding which is a special case of dipole-dipole IMFs. Dimethylether has no hydrogens bound to a highly electronegative atom, thus it cannot hydrogen bond and its only IMF is the much weaker induced dipole-induced dipole force (also called London dispersion forces). Dispersion forces are much weaker, so dimethylether has a much lower VP, BP, MP and ΔH_{vap} since less energy is required to separate molecules since they are less attracted to each other than those of ethanol.

DIF: Medium OBJ: 2.13 NAT: 1.4 TOP: IMFs
KEY: bonding | isomer | hydrogen bond | energy NOT: 62% answered correctly

AP Chem - Unit 7 Exam Key

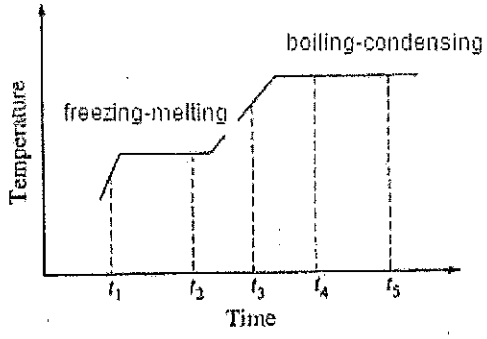
ANS: B



Phase changes occur at constant temperature! So it had to be either t_2 or t_4. AND the graph progresses from solid to liquid to vapor, so freezing/melting is the first horizontal section of the graph.

DIF: Medium OBJ: 3.11 NAT: 1.5 | 4.4 TOP: States of Matter
KEY: phase change diagram NOT: 56% answered correctly

10. ANS: A



It is an equilibrium process at t_4, but its the liquid and gas phases that are in equilibrium. Boiling begins once the vapor pressure of the system reaches atmospheric pressure, the molecules are spreading farther apart as any IMFs are being overcome and the temperature remains constant during any phase change.

DIF: Medium OBJ: 5.6 NAT: 2.2 | 2.3 TOP: States of Matter
KEY: phase change NOT: 58% answered correctly

KEY: equilibrium | phase change | grand daddy equation NOT: 34% answered correctly

11. ANS: A
For a substance to boil, the IMFs of the liquid state must be overcome.

All of these gases are noble gases. The more electrons present, the larger the noble gas, the more polarizable the cloud, the more likely induced dipole- induced dipole (London or dispersion) forces are to occur. The halogens make a great example as well.

DIF: Medium OBJ: 2.12 NAT: 5.1 | 6.5 TOP: IMFs
KEY: states of matter | gases | boiling point NOT: 62% answered correctly

12. ANS: C
For a substance to dissolve in water it must be attracted to polar water molecules. All of these gases are noble gases and are uber nonpolar. The more electrons present, the larger the noble gas, the more polarizable the cloud, the more likely induced dipole-dipole forces are to occur (a.k.a. London or dispersion forces LDFs).

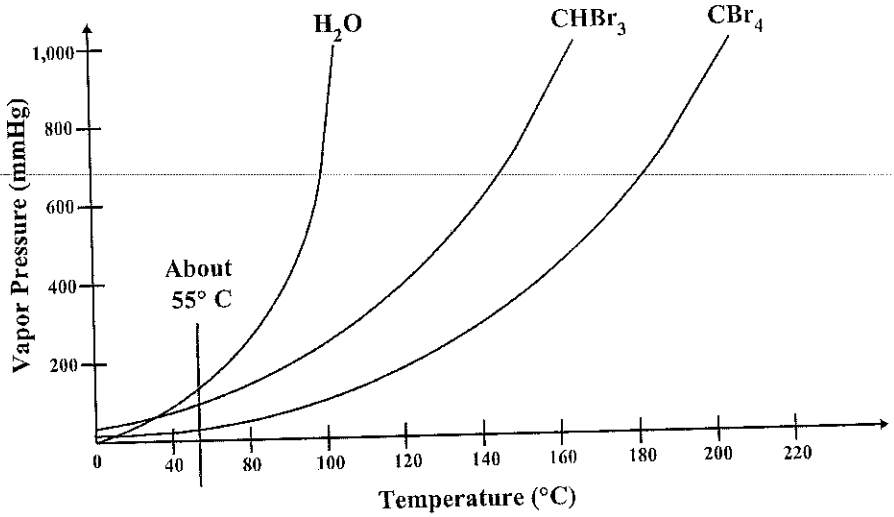
DIF: Medium OBJ: 2.12 NAT: 6.1 | 6.5 TOP: IMFs
KEY: states of matter | gases | boiling point | solubility NOT: 62% answered correctly

AP Chem - Unit 7 Exam - Key

13 ANS: D
Strontium and barium are in the same family of metals with similar MPs. Larger nonmetal-nonmetal combinations may also have high melting points (think petroleum products like "oil") due to high dispersion forces, but the hydrocarbon and/or nonmetal-nonmetal distractors for this question are of low molecular weight and are both gases. Ionic substances have the higher melting points and obey Coulomb's Law. KCl and $CaCl_2$ have very similar MP's. So, we are left with the unequal pairing of a high MP ionic substance with a low MP hydrocarbon, propane which is a gas at room temperature. There's almost 1,000 degrees C between their melting points!

DIF: Medium OBJ: 2.28 NAT: 1.1 | 6.2 | 7.1 TOP: IMFs | States of Matter | Periodicity
KEY: IMFs | melting point | dispersion forces | Coulomb's Law

14 ANS: A
Examine the graph.



DIF: Medium OBJ: 2.15 | 2.32 NAT: 6.2 | 1.1 | 7.1 TOP: IMFs | States of Matter
KEY: boiling point | vapor pressure | IMFs

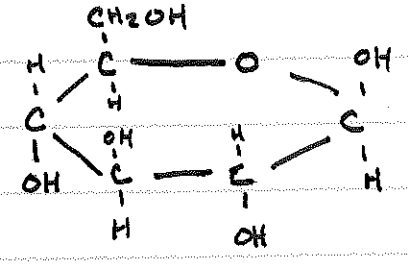
15. ANS: D
The vapor pressure above a liquid is dependent on the strength of the intermolecular forces within the liquid. 1-hexanol has London dispersion forces AND hydrogen bonding because of the -OH group on the molecule. Relative to 1-hexanol, hexane, a very non-polar molecule with a similar number of electrons, has ONLY LDF forces and not hydrogen bonding. Therefore we would expect the IMFs within the liquid hexane to be much weaker than those of 1-hexanol, thereby resulting in a greater number of molecules escaping into the vapor phase to exert a greater vapor pressure.

DIF: easy OBJ: LO 2.16 NAT: 6.2 TOP: IMFs
KEY: hydrogen bonding | LDF | hexane | vapor pressure

AP Chem - Unit 7 Exam - FR Key

8/8

1) (i) Glucose



IMF's?

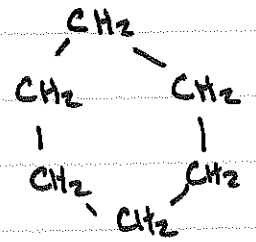
Hydrogen Bonding — 1pt
dipole-dipole interactions — 1pt
London dispersion (LDF's/Vander Waals)

(for each correct IMF up to 2 pts max)

(ii) Cyclohexane

IMF's?

London dispersion forces — 1 pt



B) Glucose soluble in H_2O, Cyclohexane not <u>Explain</u>

- The hydroxl groups in glucose molecules can form strong hydrogen Bonds w/ the solvent (H_2O) — 1pt
  ∴ glucose is soluble in H_2O
- In contrast cyclohexane can not form any strong IMF w/ H_2O (no hydrogen Bonds) — 1pt

<u>OR</u>

- Glucose is polar & cyclohexane is nonpolar — 1pt
- Polar solutes (like Glucose) are generally soluble in Polar solvents such as water — 1pt
- Nonpolar solutes (cyclohexane) are not soluble in polar solvent — 1pt

(1 pt earned for any 3 concepts: max 2)

Unit 7 Exam - FR Key

1) cont:

c)(i) In process 1 hydrogen Bonds (or dipole-dipole) in liquid water are overcome to produce distinct water molecules in the vapor phase 1pt

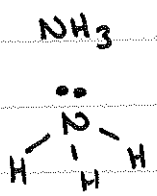
In process 2, Covalent Bonds (or sigma Bonds) within water molecules must be Broken to Allow the Atoms to recombine into molecular hydrogen & oxygen 1pt

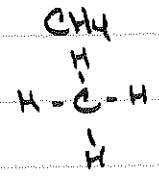
(ii) I disagree, Boiling is simply Process 1, in which only Intermolecular forces are Broken & the H_2O molecules stay Intact. 1pt
NO Intramolecular or Covalent Bonds Broken

AP Chem - Unit 7 Exam - FR Key

6/6 2)

A)





BP $-33^{\circ}C$ $-164^{\circ}C$

(1pt)

2pt NH_3 has a higher BP than CH_4, Because NH_3 is capable of hydrogen Bonding. The hydrogen bonds result in more energy being necessary to break (1pt) the Atoms Apart from one another so that they may enter the GAS phase

B) Both ethane & hexane have London dispersion forces. But hexane has a greater molar mass (1pt)

2pt ∴ more electrons ⇒ greater polarizability
so takes more energy (↑ temp) to Breake its (1pt) IMF's and Allow it to Become a gAS

C) Si is a network Collalent solid and has a much Stronger force of attraction than the Cl molecules

1pt are linear & w/ No dipole movement, so Smaller intermolecular forces ∴ Cl gAs at Room Temp.

D) MgO has a larger charge difference ($2^+ + 2^-$) than

1pt NaF, which means it has more lattice energy

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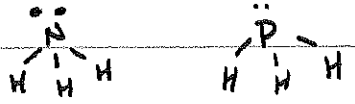
2) cont'd NH_3 PH_3

E)



Ammonia is more soluble in H_2O than PH_3 because

1 pt NH_3 molecules <u>can</u> hydrogen-bond w/ H_2O molecules, whereas PH_3 molecules <u>cannot</u> hydrogen w/ H_2O molecules

3) A) Pyridine is slightly polar & can have hydrogen bond with H_2O molecule ∴ soluble in H_2O

2 pts Benzene is nonpolar & only has London dispersion forces so insoluble in water

B) which ↓ VP?

AP Chem - Unit 7 Exam - FR Key

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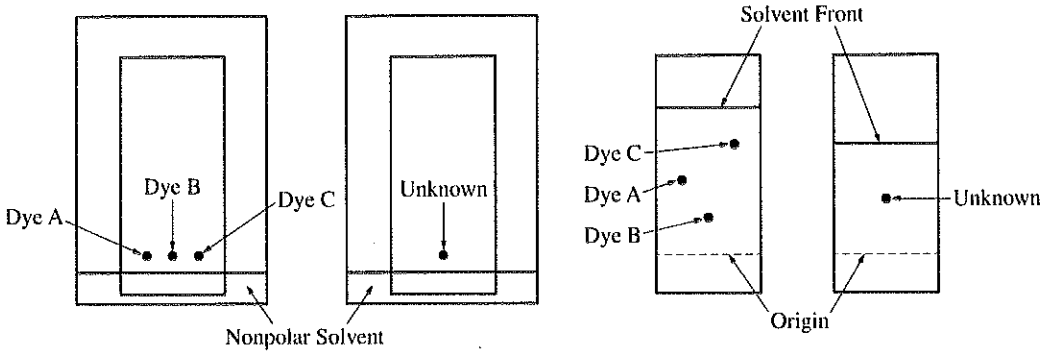
Question 4



4/4

A student investigates various dyes using paper chromatography. The student has samples of three pure dyes, labeled A, B, and C, and an unknown sample that contains one of the three dyes. The student prepares the chromatography chambers shown above on the left by putting a drop of each dye at the indicated position on the chromatography paper (a polar material) and standing the paper in a nonpolar solvent. The developed chromatograms are shown above on the right.

(a) Which dye (A, B, or C) is the least polar? Justify your answer in terms of the interactions between the dyes and the solvent or between the dyes and the paper.

Dye C is the least polar because it moved the farthest. Nonpolar dyes are more strongly attracted to the nonpolar solvent. AND/OR Nonpolar dyes are least strongly retained by the polar paper.	1 point is earned for the correct choice **and** reference to the chromatogram. 1 point is earned for a correct description of dye-solvent **and/or** dye-paper interactions.

(b) Which dye is present in the unknown sample? Justify your answer.

Dye A is present in the unknown sample. The unknown sample moves to a position that is midway between the origin and the solvent front, and so does dye A. OR Dye A has a retention factor (R_f) that is close to 0.50 on the chromatogram with the three dyes, and the unknown also has a retention factor close to 0.50.	1 point is earned for the correct choice. 1 point is earned for a valid justification.

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