Recitation Worksheet 1 (10.1-10.2 and 10.8-10.9)

Name: Key

MyID:

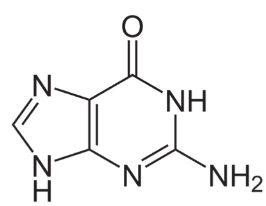
Instructions:

1. Please enter your first and last name as it appears on the eLC classlist (do not use a nickname).
2. Your UGA myID is a combination of letters and numbers (example: Dr. Abdelrahman MyID is ema88805). **Do not use your 81x number.**
   a. If you do not have access to a printer, type your answers in the worksheet PDF and then upload it to **Gradescope** by Friday, January 27th at 11:59 pm. Write your work on separate sheets of paper, convert to a PDF and upload to the "Recitation Worksheet 1 Dropbox" on eLC.
   b. If you are using an app to annotate the worksheet, make sure the pages are in the correct order and have the same layout as the original or Gradescope will not be able to read it.
   c. If you have access to a printer, print out the worksheet, write your answer in the answer boxes, and show your work on it when appropriate. Then convert it to a PDF and upload to **Gradescope** by Friday, January 27th at 11:59 pm. You do not need to upload anything to eLC. The pages must be in the correct order and have the same layout as the original, or Gradescope will not be able to read it.
   d. There is a **Gradescope App** available for both iOS and Android devices that allows you to scan and submit your printed work or you can submit your fillable PDF directly. Detailed instructions on how to access and use the app can be found on your CHEM 1212 class eLC page under content ⟶ Welcome module ⟶ Gradescope ⟶ Gradescope new mobile app.
3. Answers must be written in the corresponding answer box, or no credit will be awarded.
4. The instructions for uploading worksheets to Gradescope can be found in the Content area of eLC in the Welcome Module.

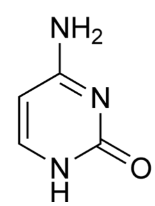
1. Double-stranded DNA consists of nucleobases that tie the DNA strands together. Nucleobases form specific pairs via intermolecular forces, example guanine pairs with cytosine. What is the **major** intermolecular force that exists between guanine and cytosine?

C

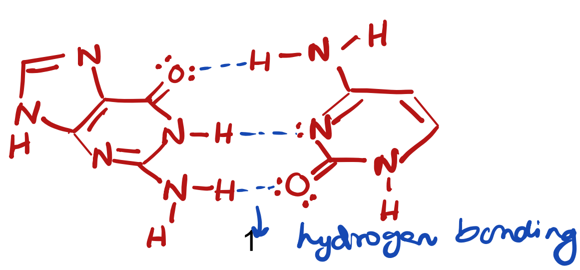
A. London dispersion forces
B. Dipole-dipole forces
C. Hydrogen bonding
D. Ion-dipole forces



Guanine



Cytosine

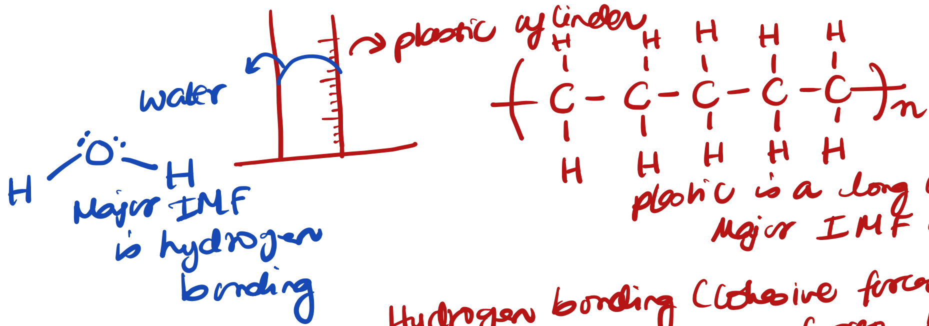


Shape of the meniscus depends on the balance between cohesive & adhesive forces

2. If water is placed in a plastic graduated cylinder, an inverted "U-shaped" meniscus is observed. The reason behind the inverted "U-shaped" meniscus is

A

A. The cohesive forces between the water molecules are stronger than the adhesive forces between the water molecules and the walls of the container
B. The viscosity of the water is greater than the viscosity of the plastic
C. Surface tension of the water prevents it from "beading up" inside the container
D. The molecules of water are forced closer together because of London forces
E. The cohesive forces between the water molecules are weaker than the adhesive forces between the water molecules and the walls of the container



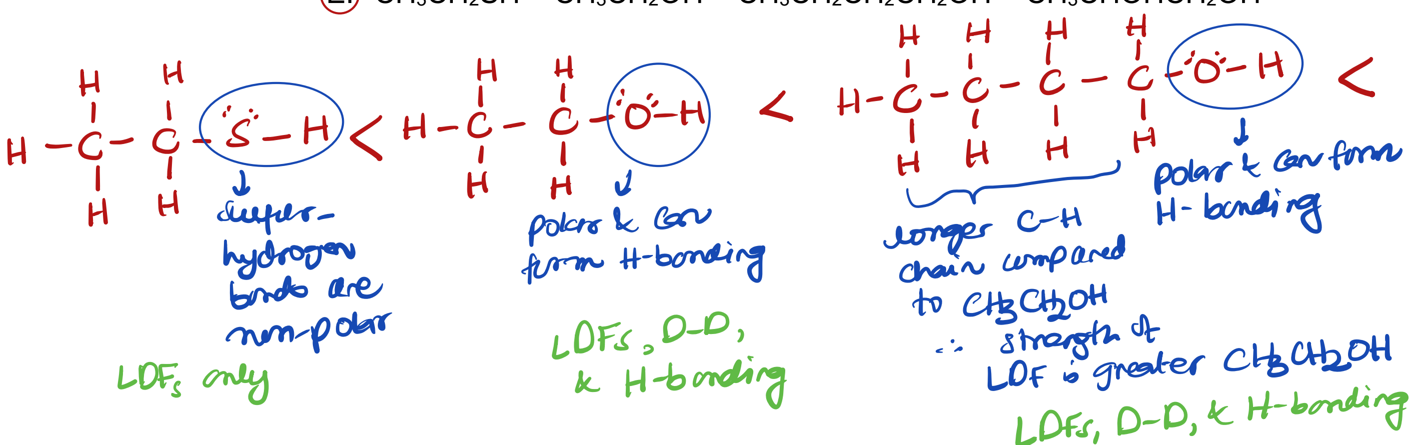
Hydrogen bonding (cohesive forces in water) is greater than the adhesive forces between H_2O (H bonding) & plastic container LDF → meniscus acquires inverted -U shape

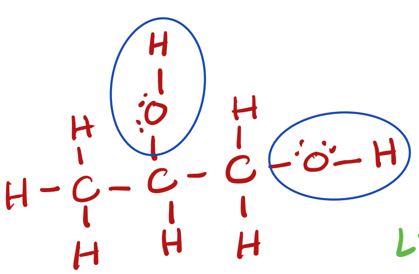
3. Which of the choices below from A – E represents the correct order of the compounds below in **order of increasing** viscosity? → viscosity is related to the strength of IMFs

$CH_3CHOHCH_2OH$ CH_3CH_2OH CH_3CH_2SH $CH_3CH_2CH_2CH_2OH$

E

A. $CH_3CHOHCH_2OH < CH_3CH_2OH < CH_3CH_2SH < CH_3CH_2CH_2CH_2OH$
B. $CH_3CH_2CH_2CH_2OH < CH_3CH_2SH < CH_3CH_2OH < CH_3CHOHCH_2OH$
C. $CH_3CHOHCH_2OH < CH_3CH_2CH_2CH_2OH < CH_3CH_2OH < CH_3CH_2SH$
D. $CH_3CH_2OH < CH_3CH_2SH < CH_3CH_2CH_2CH_2OH < CH_3CHOHCH_2OH$
E. $CH_3CH_2SH < CH_3CH_2OH < CH_3CH_2CH_2CH_2OH < CH_3CHOHCH_2OH$





capable of forming two H-bonds

LDFs, D-D, & H-bonding

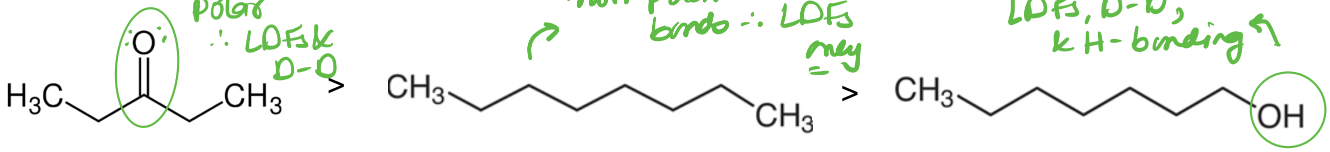
↗ vapor pressure is related to the strength of IMFs
the stronger the IMFs the lower the vapor pressure & vice versa

4. At room temperature, the vapor pressure pattern is pentanone > octane > heptanol. Which one of the following statements is **FALSE**?

Polar ∴ LDFs & D-D

non-polar bonds ∴ LDFs only

LDFs, D-D, & H-bonding



Pentanone	Octane	Heptanol
Molar mass = 86.13 g/mol	Molar mass = 114.23 g/mol	Molar mass = 116.20 g/mol

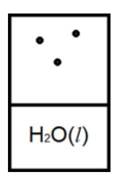
Answer: E

A. A substance with higher vapor pressure is held together by weaker binding forces ✓
B. Heptanol has the lowest vapor pressure and strongest intermolecular force due to hydrogen bonding ✓
C. Octane has lower vapor pressure than pentanone due to London dispersion forces ✓
D. Heptanol would have a higher boiling point than octane ✓
E. Pentanone would have a higher boiling point than octane ✗

* Note that pentanone has a higher vapor pressure than octane although pentanone has dipole-dipole forces. When sizes of molecules are different, LDFs are more significant than D-D forces

Pentanone has a lower vapor pressure than octane ∴ it will have a lower boiling point

5. Below is a representation of liquid water in equilibrium with its water vapor in a rigid container at 20.0 °C. The circles represent water vapor. (One dot = 100 mm Hg)

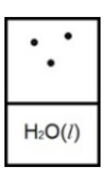


→ if one dot = 100 mmHg
∴ 3 dots = 300 mmHg → P_1
20.0°C + 273.15 = 293.2 K → T_1

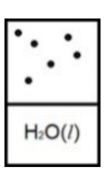
Which diagram below best represents liquid water in equilibrium with its water vapor at 32.7 °C? The heat of vaporization of water is 40.7 kJ/mol. (R = 8.314 J/K·mol)

Answer: B

A.



B.



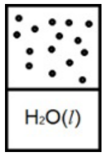
You can determine the vapor pressure at this temperature using the Clausius–Clapeyron equation

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

P_1 = 300 mm Hg
T_1 = 293.2 K
T_2 = 32.7°C + 273.15 = 305.9 K

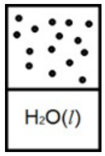
P_2 = ?
ΔH_{vap} = 40.7 kJ/mol or 4.07×10^4 J/mol
R = 8.314 J/mol·K

C.



$$\ln\left(\frac{P_2}{300}\right) = \frac{4.07\times10^4 \frac{J}{mol}}{8.314 \frac{J}{mol\cdot K}}\left(\frac{1}{293.2} - \frac{1}{305.9}\right)\frac{1}{K}$$

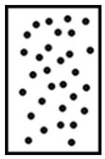
D.



$$\ln\left(\frac{P_2}{300}\right) = 0.6931778$$

$$\frac{P_2}{300} = e^{0.6931778}$$

E.



$$\frac{P_2}{300} = 2.000$$

$$\therefore P_2 = 600 \text{ mmHg}$$

$$\frac{\text{one dot}}{100 \text{ mmHg}} \times 600 \text{ mmHg} = 6 \text{ dots}$$ represents the new vapor pressure at 32.7°C

6. A vapor volume of 1.17 L forms when a sample of liquid acetonitrile, CH_3CN absorbs 1.00 kJ of heat at its normal boiling point (81.6 °C and 1 atm). What is ΔH_{vap} in kJ/mol of CH_3CN? (**Hint:** you can use the ideal gas law to solve this problem). Keep your answers to two sig figs.

25	kJ/mol

① Determine the number of moles using the ideal gas law

PV = nRT (ideal gas law)

P = 1 atm

V = 1.17 L

n = ?

$R = 0.08206 \frac{L\cdot atm}{mol\cdot K}$

T = 81.6°C + 273.15 = 354.8 K

$$\therefore n = \frac{1 \text{ atm} \times 1.17 \text{ L}}{0.08206 \frac{L\cdot atm}{mol\cdot K} \times 354.8 \text{ K}} = 0.04018 \text{ mol}$$

② $$\Delta H_{vap} = \frac{1.00 \text{ kJ}}{0.04018 \text{ mol}} = 24.88 \sim 25 \text{ kJ/mol}$$

7. For a particular liquid, raising its temperature from 25 °C to 45 °C causes its vapor pressure to double. What is the enthalpy of vaporization of this liquid?

C

A. 115 kJ/mol
B. 288 kJ/mol
C. 27.3 kJ/mol
D. 2.53 kJ/mol
E. 270 kJ/mol

$T_1 = 25°C + 273.15 = 298.2\,K$

$T_2 = 45°C + 273.15 = 318.2\,K$

Increasing the temperature from T_1 to T_2 doubles the vapor pressure ∴ you can assume that $\frac{P_2}{P_1} = \frac{2}{1}$

Using Clausius-Clapeyron equation:

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\ln\left(\frac{2}{1}\right) = \frac{\Delta H_{vap}}{8.314}\left(\frac{1}{298.2} - \frac{1}{318.2}\right)$$

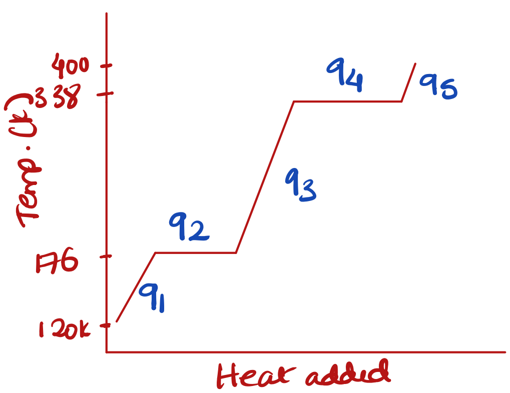
$$\Delta H_{vap} = 2.73 \times 10^4 \frac{J}{mol} \times \frac{1\,kJ}{1000\,J} = 27.3 \frac{kJ}{mol}$$

8. What quantity of energy in kJ does it take to convert 0.250 kg of solid methanol (CH_3OH) at 120 K to gaseous methanol at 400 K? Keep your answer to two sig figs.

460 or	kJ

4.6×10^2 kJ

Melting point	176 K
Boiling point	338 K
Heat of fusion	2.2 kJ/mol
Heat of vaporization	35.2 kJ/mol
Specific heat (solid)	105 J/mol·K
Specific heat (liquid)	81.3 J/mol·K
Specific heat (gas)	48.0 J/mol·K



$q_1 = m \cdot C \cdot \Delta T = 2.50 \times 10^2\,g \times \frac{1\,mol}{32.04\,g} \times \frac{105\,J}{mol \cdot K} \times (176.0 - 120.0)\,K = 4.58801 \times 10^4\,J = 45.8801\,kJ$

$q_2 = n \times \Delta H_{fus} = 2.50 \times 10^2\,g \times \frac{1\,mol}{32.04\,g} \times 2.2 \frac{kJ}{mol} = 17.1660\,kJ$

$q_3 = m \cdot C \cdot \Delta T = 2.50 \times 10^2\,g \times \frac{1\,mol}{32.04\,g} \times 81.3 \frac{J}{mol \cdot K} (338.0 - 176.0)\,K = 102.7669\,kJ$

$q_4 = n \times \Delta H_{vap} = 2.50 \times 10^2\,g \times \frac{1\,mol}{32.04\,g} \times 35.2 \frac{kJ}{mol} = 274.6567\,kJ$

$q_5 = m \cdot C \cdot \Delta T = 2.50 \times 10^2\,g \times \frac{1\,mol}{32.04\,g} \times 48.0 \frac{J}{mol \cdot K} \times (400.0 - 338.0)\,K = 23.2331\,kJ$

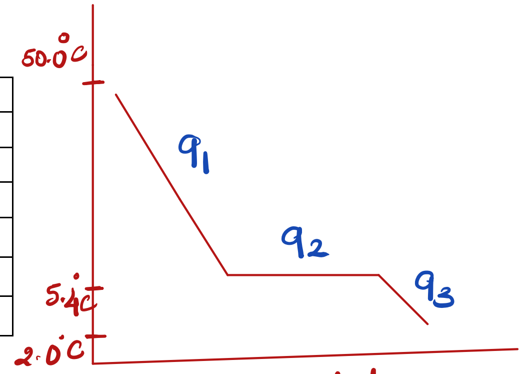
$Q_{total} = q_1 + q_2 + q_3 + q_4 + q_5 = (45.8801 + 17.1660 + 102.7669 + 274.6567 + 23.2331) = 463.7021\,kJ \approx 460\,kJ$

9. Calculate the quantity of heat released in kJ when 15.7 g of benzene (C_6H_6) in the liquid phase at 50.0 °C is converted to solid benzene at 2.0 °C. Keep your answer to two sig figs.

−3.3	kJ

or
3.3 kJ of heat released

Melting point	5.4 °C
Boiling point	90.1 °C
Heat of fusion	9.9 kJ/mol
Heat of vaporization	30.7 kJ/mol
Specific heat (solid)	1.51 J/g·°C
Specific heat (liquid)	1.80 J/g·°C
Specific heat (gas)	1.92 J/g·°C



$q_1 = m \cdot C \cdot \Delta T = 15.7\,g \times 1.80 \frac{J}{g \cdot °C} \times (5.4 - 50.0)°C = -1.2603$ kJ

$q_2 = n \times \Delta H_{fus} = 15.7\,g \times \frac{1\,mol}{78.11\,g} \times -9.9 \frac{kJ}{mol} = -1.9899$ kJ

$q_3 = m \cdot C \cdot \Delta T = 15.7\,g \times 1.51 \frac{J}{g \cdot °C} \times (2.0 - 5.4)°C = -0.08060$ kJ

$Q_{total} = (-1.2603) + (-1.9899) + (-0.08060\,kJ)$
$= -3.33\,kJ \approx -3.3\,kJ$

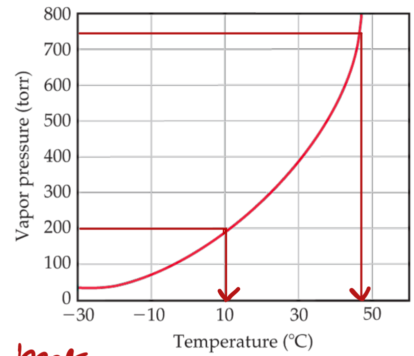
A volatile liquid is a liquid that can evaporate easily ∴ it has a high vapor pressure

10. The graph shown to the right represents the vapor pressure of CS_2, a volatile liquid. Which of the following statements regarding CS_2 is true? Select all that apply.

ABD

S=C=S linear ∴ non-polar (LDFs)

A. CS_2 has weaker intermolecular forces compared to water
B. The vapor pressure of CS_2 is greater than the vapor pressure of water weaker IMF = higher vapor pressure
C. The normal boiling point of CS_2 is approximately 30 °C
D. The vapor pressure of CS_2 is 200 torr at 10 °C



H–O–H bent polar structure
H-bonding is the major IMF

11. Indicate the **most significant** intermolecular force in each of the compounds or compound pairs below. For each molecule select one of the following choices:

A. London dispersion forces
B. Dipole-dipole forces
C. Hydrogen bond
D. Ion-dipole forces

For your answer choice insert the letters A – D in the answer box. Example, if the answer is London dispersion forces, then the answer is choice A.

D	i. LiCl (in water)

ionic compound

B	ii. Cl_3PO

although tetrahedral, the presence of oxygen breaks the symmetry of the molecule

A	iii. SF_6

Sulfur-hydrogen bonds are polar but SF_6 has an octahedral geometry resulting in a non-polar molecule

A	iv. CH_3—CH(CH_3)—CH_3

this compound has only C–H bonds which are non-polar ∴ the only type of IMF that exist is Dispersion forces

C	v. H_2NNH_2

hydrogen is covalently bonded to nitrogen (one of the three most electronegative atoms) ∴ can form hydrogen bonds.

12. Which of the following choices A – E represents the correct order of the compound below of **decreasing** vapor pressure?

↳ vapor pressure is related to the strength of IMFs. the stronger the IMF the lower the vapor pressure & vice versa

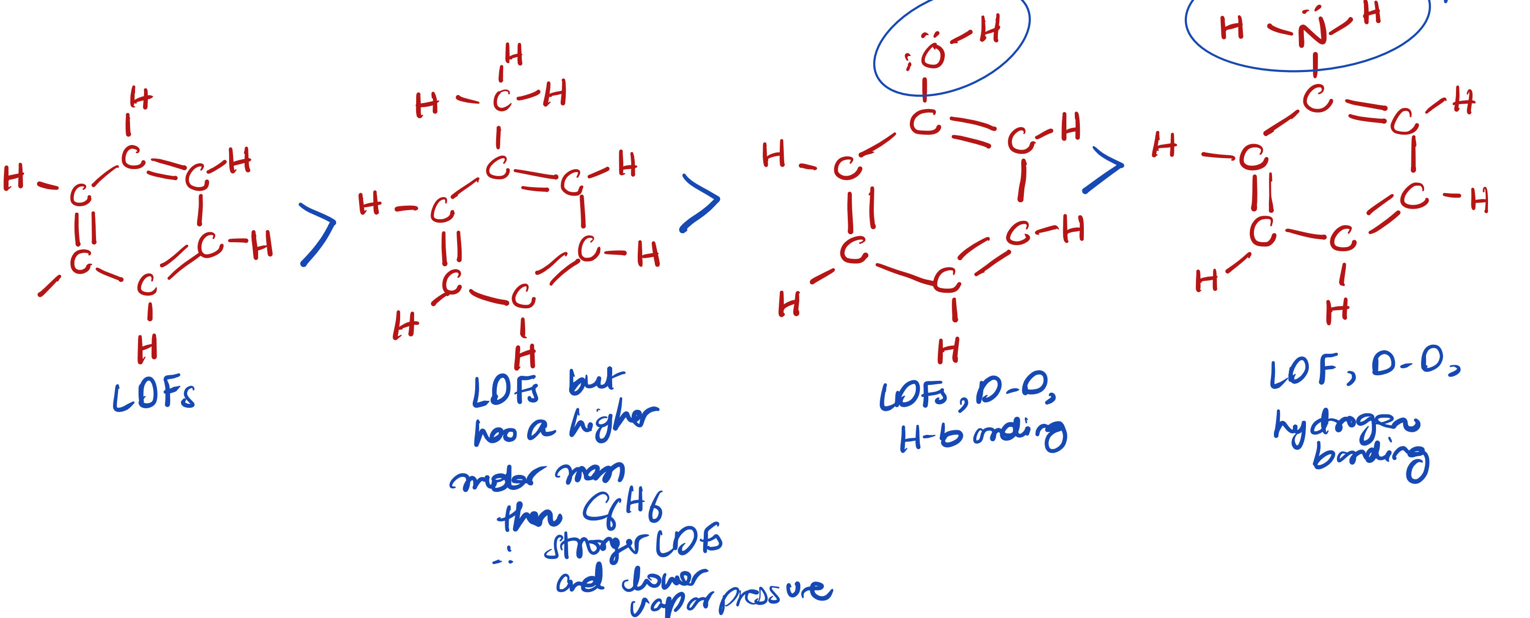
C_6H_6 C_6H_5OH $C_6H_5CH_3$ $C_6H_5NH_2$

Answer: A

A. $C_6H_6 > C_6H_5CH_3 > C_6H_5OH > C_6H_5NH_2$
B. $C_6H_5OH > C_6H_5NH_2 > C_6H_5CH_3 > C_6H_6$
C. $C_6H_5NH_2 > C_6H_5OH > C_6H_6 > C_6H_5CH_3$
D. $C_6H_5CH_3 > C_6H_6 > C_6H_5NH_2 > C_6H_5OH$
E. $C_6H_5OH > C_6H_6 > C_6H_5NH_2 > C_6H_5CH_3$

→ H-bonding

→ capable of forming more than one H-bond

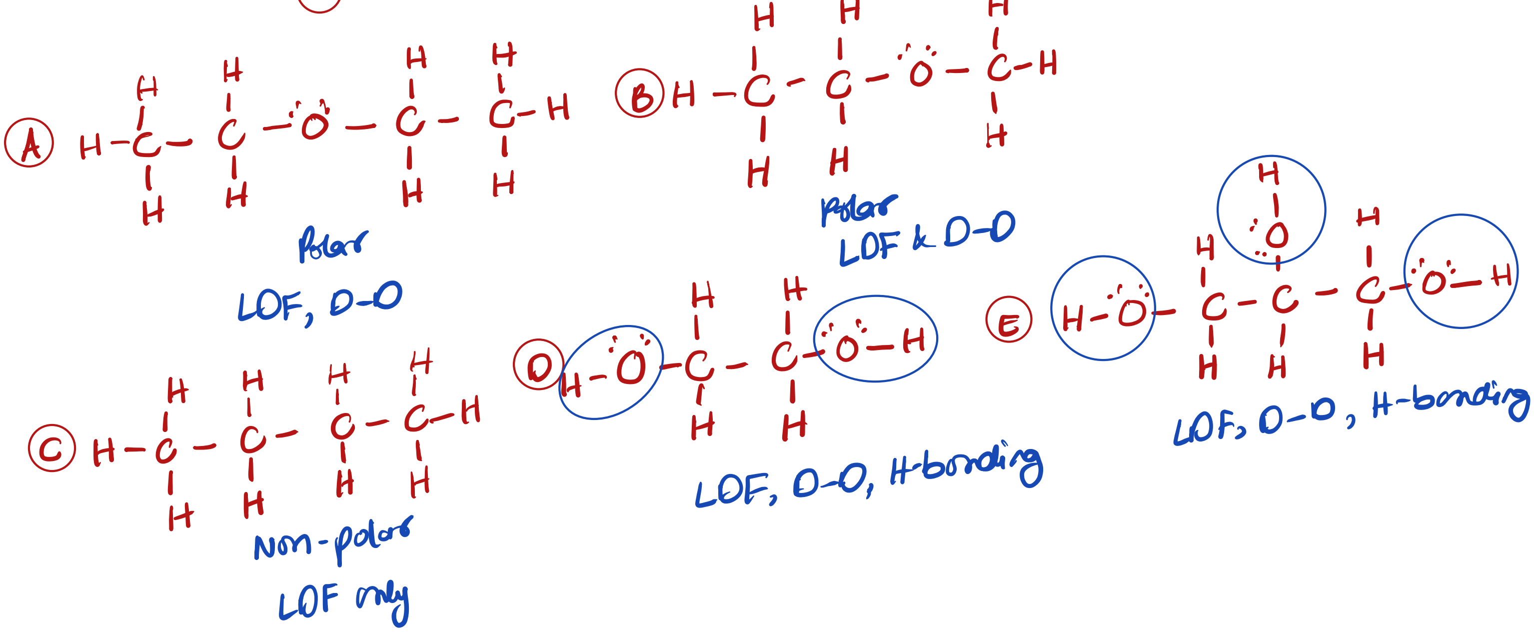


13. Which of the following compound has the **highest** surface tension?

↳ related to strength of IMFs

Answer: E

A. $CH_3CH_2OCH_2CH_3$
B. $CH_3CH_2OCH_3$
C. $CH_3CH_2CH_2CH_3$
D. $OHCH_2CH_2OH$
E. $CH_2OHCHOHCH_2OH$



14. Which statements about vapor pressure below are true? Select all that apply.

BC

A. Water in a 150 mL container volume with a diameter of 12 cm evaporates faster and therefore has a higher vapor pressure than water in a container with a volume of 75 mL and a diameter of 5.5 cm
B. The stronger the intermolecular forces between the molecules of a liquid the lower the vapor pressure
C. An increase in temperature of a liquid increases its vapor pressure
D. Normal melting point is the temperature at which the vapor pressure of a liquid is 760 torr or 1 atm.
E. All the above statements are true.

15. A liquid has an enthalpy of vaporization of 30.8 kJ/mol. At 273 K it has a vapor pressure of 102 mmHg. What is the normal boiling point of this liquid? (1mm Hg = 1 Torr)

B

A. 273 K
B. 320 K
C. 292 K
D. 238 K
E. 257 K

Using Clausius-Clapeyron Equation:

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$\Delta H_{vap} = 30.8$ kJ/mol
$R = 8.314$ J/mol·K
$P_1 = 102$ mmHg
$T_1 = 273$ K
$P_2 = 760$ mmHg
$T_2 = ?$

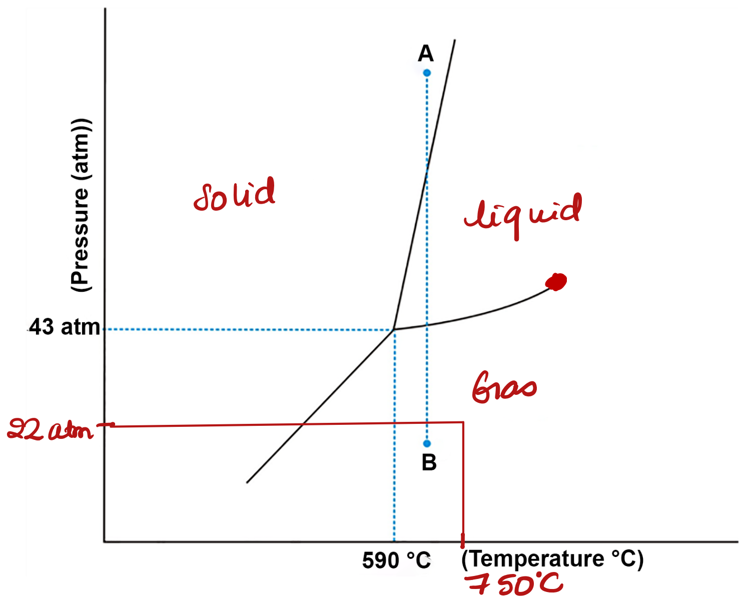
$$\ln\left(\frac{760}{102}\right) = \frac{3.08 \times 10^4 \text{ J/mol}}{8.314 \text{ J/mol·K}}\left(\frac{1}{273} - \frac{1}{T_2}\right)$$

$$5.4212290 \times 10^{-4} = \left(\frac{1}{273} - \frac{1}{T_2}\right)$$

$$\frac{1}{T_2} = 3.120880758 \times 10^{-3}$$

$\therefore T_2 = 320.42 \approx 320$ K

16. Using the phase diagram for phosphorous below, which of the following statements is correct? Select all that apply. Insert letters without spaces or commas, example**: ABCD**.

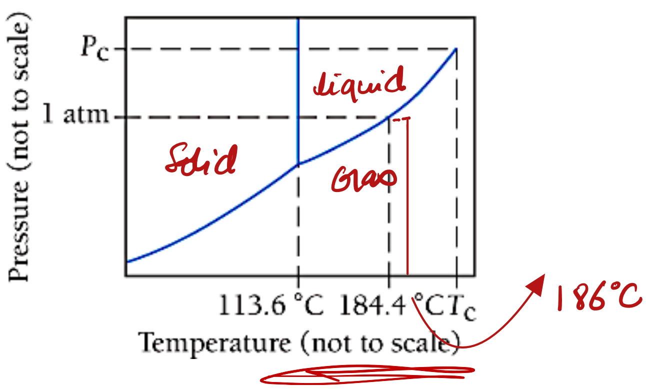


this is the triple point

BCE

A. The critical pressure and temperature of phosphorous is at 43 atm and 590 °C respectively
B. The triple point of phosphorous is at 43 atm and 590 °C
C. Phosphorous changes from solid to liquid to gas as you follow along the line AB
D. Phosphorous changes from liquid to gas to solid as you follow along the line AB
E. Phosphorous exists as a gas if it is heated at 22 atm and 750 °C

17. Using the phase diagram for iodine below, answer the following questions:



184.4

A. What is the normal boiling point for iodine?

temperature at which vapor pressure = 1 atm
You can determine that from the vaporization curve

113.6

B. What is the normal melting point for iodine?

↓ temperature at which liquid & solid phase are at equilibrium at 1 atm

Gas

C. Which state is present at 186 °C and 1.0 atm?