

General Chemistry II Jasperse
Intermolecular Forces, Ionic bond strength, Phase Diagrams, Heating Curves. Extra Practice Problems

1. Rank the ionic bond strength for the following ionic formulas, 1 being strongest:



Strategy: Identify ion charges.

2. Rank the lattice energy (ionic bond strength) for the following formulas, 1 being strongest:



Strategy: When Charges are Equal, Use Ion Size to Break Ties.

3. Rank the ionic bond strength for the following ionic formulas, 1 being strongest:



Strategy: Charge is more important than Ion Size. Use Ion size only to Break Ties.

4. Arrange the following compounds in order of increasing attraction between their ions:



5. Which of the following will require the greatest energy input to separate the ions?



6. Which of the following will have the highest melting point?



7. Which of the following requires the lowest melting point?



8. Arrange the three compounds sodium chloride, magnesium chloride, and aluminum chloride in order of increasing melting point.

- $\text{NaCl} < \text{MgCl}_2 < \text{AlCl}_3$
- $\text{MgCl}_2 < \text{NaCl} < \text{AlCl}_3$
- $\text{AlCl}_3 < \text{NaCl} < \text{MgCl}_2$
- $\text{AlCl}_3 < \text{MgCl}_2 < \text{NaCl}$
- $\text{NaCl} < \text{AlCl}_3 < \text{MgCl}_2$

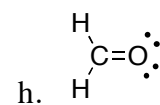
9. Rank the attractive power for water to the following, 1 being strongest:



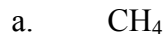
10. Ion–dipole forces always require

a.	an ion and a water molecule.	d.	an ion and a polar molecule.
b.	a cation and a water molecule.	e.	a polar and a nonpolar molecule.
c.	an anion and a polar molecule.		

11. Classify each of the following as polar (molecular), completely nonpolar (molecular), weakly polar (molecular), ionic, or metallic.



12. Which of the following compounds is capable of dipole–dipole interactions?



13. Which of the following compounds is capable of hydrogen bonding?

a.	CH_3OCH_3	d.	H_2CO
b.	CH_3COCH_3	e.	CH_3F
c.	$\text{CH}_3\text{CH}_2\text{OH}$		

14. Based on their boiling points, which of the following compounds has the largest dipole–dipole interaction? (They are all molecular, variably polar, but without hydrogen-bonding.)

a.	propane (231 K)	d.	methyl chloride (249 K)
b.	dimethyl ether (248 K)	e.	butane (135 K)
c.	acetonitrile (355 K)		

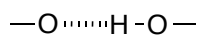
15. Classify as having network versus molecular bonding:

- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{SH}$
- $\text{P}(\text{CH}_3)_3$
- K_3PO_4
- $\text{C}_3\text{H}_7\text{OH}$
- Diamond
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$
- $\text{CH}_3\text{CH}_2\text{NHCH}_2\text{CH}_3$
- $\text{H}-\text{N}=\text{O}$
- Fe_2O_3
- CO
- Zn
- NH_3

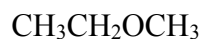
16. Which of the following polar compounds is likely to have the highest boiling point?

a.	CH_3OCH_3	d.	H_2CO
b.	$\text{CH}_3\text{CH}_2\text{OH}$	e.	CO
c.	$(\text{CH}_3)_2\text{CO}$		

17. Which of the following shows a “hydrogen bond”?



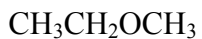
18. Which of the following will have hydrogen bonding?



19. Rank the following in terms of increasing boiling point: LiCl C₃H₇OH C₄H₈ N₂

- N₂ < LiCl < C₃H₇OH < C₄H₈
- LiCl < C₄H₈ < C₃H₇OH < N₂
- N₂ < C₄H₈ < C₃H₇OH < LiCl
- LiCl < C₄H₈ < N₂ < C₃H₇OH
- C₃H₇OH < C₄H₈ < N₂ < LiCl

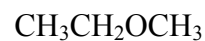
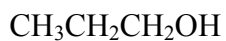
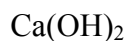
20. Which is higher boiling, and why? (Both have the same formula, C₃H₈O)



21. Rank the boiling points for the following, 1 being highest:



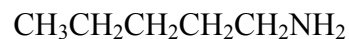
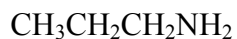
22. Rank the melting points for the following, 1 being highest:



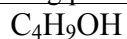
23. Rank the evaporation rate (1 being highest)



24. Rank the melting points for the following, 1 being highest:



25. Rank the following in terms of increasing boiling point:



- C₄H₁₀ < CaBr₂ < C₂H₅OH < C₄H₉OH
- CaBr₂ < C₄H₁₀ < C₂H₅OH < C₄H₉OH
- C₄H₁₀ < C₄H₉OH < C₂H₅OH < CaBr₂
- C₂H₅OH < C₄H₁₀ < C₄H₉OH < CaBr₂
- C₄H₁₀ < C₂H₅OH < C₄H₉OH < CaBr₂

26. Rank the following in terms of increasing boiling point:



- $\text{CH}_3\text{CH}_2\text{OCH}_3 < \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_2\text{OCH}_3 < \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 < \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 < \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 < \text{CH}_3\text{CH}_2\text{OCH}_3 < \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 < \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 < \text{CH}_3\text{CH}_2\text{OCH}_3 < \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$

27. For F_2 , $\text{C}_3\text{H}_7\text{OH}$, and Na_2O , which of the following is true at room temperature?

- F_2 is a gas, $\text{C}_3\text{H}_7\text{OH}$ is a liquid, and Na_2O is a solid
- Na_2O is a gas, F_2 is a liquid, and $\text{C}_3\text{H}_7\text{OH}$ is a solid
- F_2 is a gas, Na_2O is a liquid, and $\text{C}_3\text{H}_7\text{OH}$ is a solid
- $\text{C}_3\text{H}_7\text{OH}$ is a gas, F_2 is a liquid, and Na_2O is a solid

28. For CO_2 , $\text{Zn}(\text{NO}_3)_2$, and $\text{C}_5\text{H}_{11}\text{NH}_2$, which of the following is true at room temperature?

- $\text{Zn}(\text{NO}_3)_2$ is a gas, CO_2 is a liquid, and $\text{C}_5\text{H}_{11}\text{NH}_2$ is a solid
- CO_2 is a gas, $\text{C}_5\text{H}_{11}\text{NH}_2$ is a liquid, and $\text{Zn}(\text{NO}_3)_2$ is a solid
- CO_2 is a gas, $\text{Zn}(\text{NO}_3)_2$ is a liquid, and $\text{C}_5\text{H}_{11}\text{NH}_2$ is a solid
- $\text{C}_5\text{H}_{11}\text{NH}_2$ is a gas, CO_2 is a liquid, and $\text{Zn}(\text{NO}_3)_2$ is a solid

29. The highest vapor pressure is observed for which of the following liquid/temperature combinations?

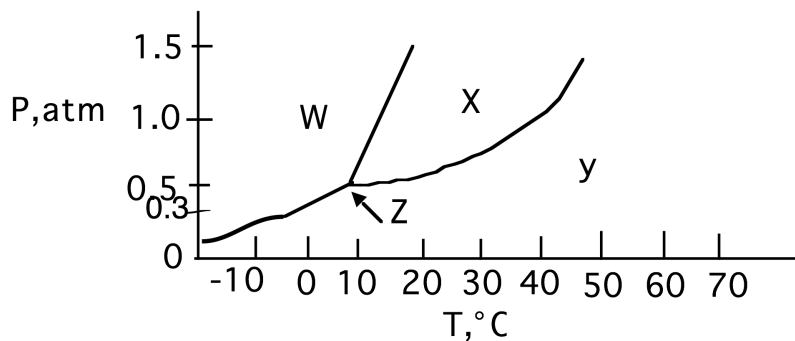
- C_6H_{14} at 275 K
- C_6H_{14} at 299 K
- C_5H_{12} at 299 K
- $\text{HOC}_4\text{H}_8\text{OH}$ at 299 K
- $\text{HOC}_4\text{H}_8\text{OH}$ at 275 K

30. Which of the following liquids would have the lowest vapor pressure, factoring in both the impact of the substance and the temperature?

- CH_3NH_2 at 25°C
- SiH_4 at 75°C
- SiH_4 at 25°C
- $\text{C}_3\text{H}_7\text{NH}_2$ at 25°C
- $\text{C}_3\text{H}_7\text{NH}_2$ at 75°C

31. Which of the following liquids would have the lowest viscosity, factoring in both the impact of the substance and the temperature?
- C_3H_7OH at $25^\circ C$
 - C_3H_7OH at $75^\circ C$
 - $MgBr_2$ at $25^\circ C$
 - $C_5H_{11}OH$ at $25^\circ C$
 - $C_5H_{11}OH$ at $75^\circ C$
32. CH_2F_2 has a dipole moment of 1.93 D and a boiling point of $-52^\circ C$. CH_2Cl_2 has a dipole moment of 1.60 D and a boiling point of $40^\circ C$. Why is the boiling point of dichloromethane 92° higher than that of difluoromethane? Which of the following explains why dichloromethane has the higher boiling point?
- CH_2F_2 is more polar and thus must have stronger binding forces. With stronger intermolecular attraction, of course CH_2F_2 will have a lower boiling point.
 - CH_2Cl_2 is ionic while CH_2F_2 is molecular.
 - CH_2Cl_2 has hydrogen-bonding while CH_2F_2 does not.
 - That CH_2Cl_2 has a higher boiling point proves that it has stronger intermolecular attractions, even though CH_2F_2 has a larger dipole moment. Evidently CH_2Cl_2 has larger London dispersion attraction, which is more than making up for its smaller permanent dipole.
33. HCl (mw=36.5) has a dipole moment of 1.03 D and a boiling point of 190K. HBr (mw=80.9) has a dipole of 0.79 D and a boiling point of 206K. Which of the following statements is true?
- HBr is more polar.
 - HCl has stronger intermolecular forces.
 - HCl has stronger London dispersion forces
 - Both molecules have hydrogen bonding.
 - That HBr has a higher boiling point proves that it has stronger intermolecular attractions, despite its lesser dipole moment. Evidently with its extra mass it has much stronger London dispersion attraction, enough so to overcome the dipole advantage of HCl.
34. Hexane, C_6H_{14} (mw=86) has a boiling point of 68° . Ethanol, CH_3CH_2OH (mw=46) has a boiling point of 78° . Mark each of the following statements as TRUE or FALSE.
- Ethanol must have stronger intermolecular attraction, based on its higher boiling point.
 - Ethanol has a higher boiling point because of greater London dispersion force
 - Both hexane and ethanol have hydrogen bonding.
 - Ethanol has a higher boiling point due to hydrogen bonding.
 - Hydrogen bonding and London dispersion forces are at cross purposes here. (One favors ethanol, the other favors hexane.) In this case, the hydrogen bonding evidently “wins”.
35. Viscosity is a measure of a substance's _____
- | | | | |
|----|--|----|------------------|
| a. | ability to resist changes in its surface area. | d. | compressibility. |
| b. | surface tension. | e. | color. |
| c. | resistance to flow. | | |

Phase Diagrams



36. Which letter represents:

- a. Gas Phase b. Liquid c. Solid d. Triple Point

37. What is the normal bp?

- a) 20° b) 40° c) 65° d) 80°

38. What is the normal mp?

- a) 12° b) 40° c) 80°

39. When a liquid originally at 20° and 1 atm has pressure reduced, at what pressure will it vaporize?

40. When a liquid originally at 20° and 1 atm has pressure increased, at what pressure will it solidify?

41. When solid at 1.0 atm is warmed, does it: a) melt or b) sublime

42. When solid at 0.3 atm is warmed, does it: a) melt or b) sublime

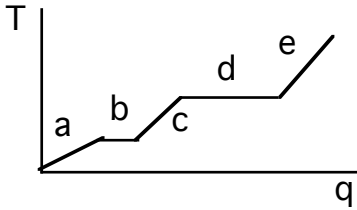
43. Suppose a solid is originally at 0.3 atm and 0°C. If it is first pressurized to 1.0 atm, and then subsequently heated to 60°C, what will happen to it?

- It will sublime directly to gas
- It will melt and end up as a liquid
- It will first melt, and then boil, ending up as a gas
- It will sublime to gas, then compress to a liquid and end up in the liquid phase
- No phase change will happen. It will just stay solid.

44. Suppose a solid is originally at 0.3 atm and 0°C. If it is first heated to 30°C, then pressurized to 1.0 atm, what will happen to it?

- It will sublime directly to gas and stay a gas.
- It will melt and end up as a liquid
- It will first melt, and then boil, ending up as a gas
- It will sublime to gas first, then compress to a liquid and end up in the liquid phase
- No phase change will happen. It will just stay solid.

Heating Curves



45. Which regions on the heating curve shown (Temperature versus heat, “q”) corresponds to:
- a pure gas increasing in temperature
 - a liquid increasing in temperature
 - a solid increasing in temperature
 - a solid melting
 - a liquid boiling
46. On the above heating curve, which phases are present:
- in region “a”
 - in region “b”
 - in region “c”
 - in region “d”
 - in region “e”

General Chemistry II Jasperse
 Intermolecular Forces, Ionic bond strength, Phase Diagrams, Heating Curves. Extra Practice Problems

Answers

1. 1-2-3-4 ($\text{Al}_2\text{S}_3 > \text{MgO} > \text{MgCl}_2 > \text{NaCl}$) Ion charge
2. 1-2-3-4-5 ($\text{LiF} > \text{NaF} > \text{NaCl} > \text{NaI} > \text{KI}$) (Ion size)
3. 3-5-4-1-2 ($\text{Fe}_3\text{N}_2 > \text{CaO} > \text{Na}_2\text{O} > \text{LiCl} > \text{NaBr}$) (Ion size first, then size as tiebreaker)
4. 1-2-3 ($\text{MgO} > \text{CaO} > \text{BaO}$)
5. b
6. a
7. b (this is for corrected version of question. Original version had a confusion factor included)
8. a
9. 1-2-3-4 ($\text{Mg}^{2+} > \text{Na}^+ > \text{H-Br} > \text{N}_2$)
10. d
11. Classify
 - a. Nonpolar
 - b. Polar
 - c. Nonpolar
 - d. Polar
 - e. Weakly polar
 - f. Polar
 - g. Polar
 - h. Polar
 - i. Nonpolar
 - j. Metal
 - k. Ionic
12. C
13. C
14. C
15. Classify
 - a. Molecular
 - b. Molecular
 - c. Network
 - d. Molecular
 - e. Network
 - f. Molecular
 - g. Molecular
 - h. Molecular
 - i. Network
 - j. Molecular
 - k. Network
 - l. Molecular
16. B
17. Which show a "hydrogen bond"

$$\text{-O}\cdots\text{H-N-}$$

$$\text{-N}\cdots\text{H-N-}$$

$$\text{-O}\cdots\text{H-O-}$$

$$\text{-O}\cdots\text{H-N-}$$
18. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, $\text{CH}_3\text{CH}_2\text{NH}_2$
19. C
20. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
21. 3-2-1

22. 1-3-2-4 ($\text{Ca}(\text{OH})_2 > \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} > \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} > \text{CH}_3\text{CH}_2\text{OCH}_3$)
23. 4-3-1-2 ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 > \text{CH}_3\text{CH}_2\text{OCH}_3 > \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} > \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$)
24. 3-1-4-2 ($\text{LiCl} > \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 > \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 > \text{N}(\text{CH}_3)_3$)
25. e
26. b
27. a
28. b
29. c
30. d
31. b
32. d
33. e
34. a, d, and e are all true.
35. c
36. Y-X-W-Z
37. B
38. A
39. About 0.5 atm
40. About 1.5 atm
41. Melt
42. Sublime
43. C
44. d
45. e-c-a-b-d
46.
 a. solid
 b. solid + liquid
 c. liquid
 d. liquid + gas
 e. gas