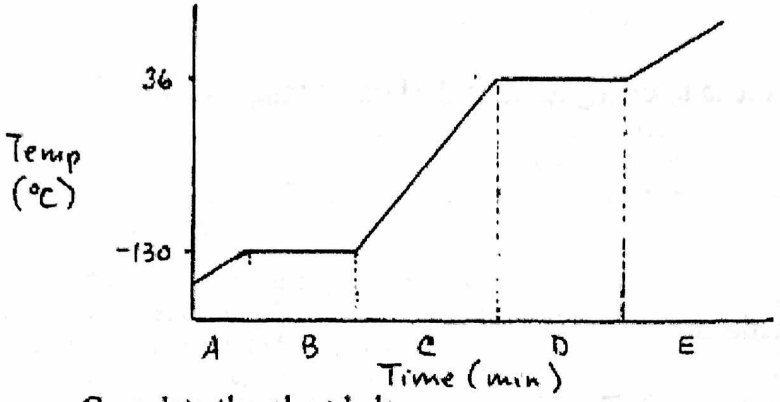
Phase Changes

1. Use the graph below to answer the questions.



Heating curve for pentane (starting as solid)

a. Complete the chart below.

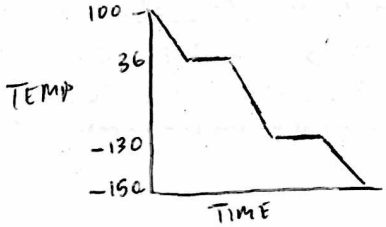
	A	B	C	D	E
What state(s) is/are present?	SOLID	SOLID & LIQUID	LIQUID	LIQUID & GAS	GAS
What is happening to substance?	↑ KE	MELTING	↑ KE	BOILING	↑ KE

b. What is the melting temperature of pentane? The freezing temperature? The boiling temperature? The condensing temperature?

M.P. / F.P. = −130 °C

B.P. / C.P. = 36 °C

c. Sketch the cooling curve for pentane as it cools from 100 °C to -150 °C.



2. What kinds of forces between particles affect the boiling temperature of

a. ionic substances?

- ELECTROSTATIC ATTRACTION BETWEEN IONS
- SIZE OF IONS

c. molecular substances?

H – BONDING LONDON DISPERSION FORCES

DIPOLE – DIPOLE

3. Why do boiling temperatures of metals tend to be higher than the boiling temperatures of molecular substances?

OMIT

4. Use the table below to answer the questions.

	Mass	B. T. (°C)
1-butene	56.11	-6.3
1-pentene	70.13	30
1-hexene	84.16	63.3
1-heptane	98.19	
1-octene	112.22	121.3
1-nonene	126.24	146
1-decene	140.27	170.5

a. Predict the boiling temperature of 1-heptane.

98.42 °C (I DON'T EXPECT EXACT VALUE)

b. Alkenes are non-polar molecular substances. Explain why their boiling temperature increases when mass does in terms of forces between particles.

$KE = \frac{1}{2} m\vec{v}^2$ WHEN MASS ↑ THE $\vec{v}$ AT A GIVEN TEMP IS ↓ AND ∴ THE PARTICLES WILL BE CLOSER TOGETHER ALLOWING MORE INTERACTIONS (LONDON DISPERSION FORCES)

c. Which of the substances has the strongest forces between particles? The weakest forces? Explain how you know. ↳ 1-decene ↳ 1-butene

B.T. CORRELATES DIRECTLY TO IMF

5. Predict the state of the following substance at room temperature (25 °C). Explain how you know.

	M.T. (°C)	B.T. (°C)	
a. octane	-56.8	125.7	— LIQUID
b. sodium chloride	801	1413	— SOLID
c. carbon dioxide	-56.6	-78.5	— GAS

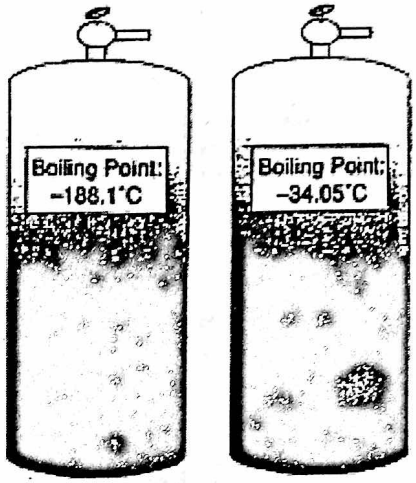
14–1 Apply

Boiling Points and Intermolecular Forces

A technician was cleaning up the laboratory when he discovered two steel gas cylinders. One cylinder was labeled *Boiling Point: –188.1*°C. The other was labeled *Boiling Point: –34.05*°C. Puzzled, the technician took the cylinders to his supervisor.

"One cylinder contains gaseous F_2 and the other contains gaseous Cl_2," said his supervisor. She then asked the technician to label the two containers correctly. He asked, "But, which is which?" The supervisor responded indignantly that, to a chemist, the answer should be obvious!

Seeing the disgruntled look on the technician's face, she offered the following hints to help him solve the problem. See if you can solve the problem using the following steps.



Hint: Boiling points are related to intermolecular attractive forces.

1. a. List the three types of intermolecular forces.

   H- BONDING ; DIPOLE – DIPOLE ; LONDON DISPERSION (LDF)

   b. Which one of these three forces is present in F_2 and Cl_2? LDF

Hint: Molecular size affects the strength of intermolecular forces.

2. Explain the effect that large molecular size has on the strength of intermolecular forces.

   ↑ SIZE = ↑ He^- AND THEREFORE ↑ LDF

   IN ADDITION ↑ MASS = ↓ $\vec{v}$ AND ∴ MORE INTERACTIONS

3. Look at the periodic table. Can you decide which molecule is larger, F_2 or Cl_2? Explain your answer.

   Cl_2 → SIZE INCREASES DOWN FAMILY

Hint: The strength of intermolecular attractive forces in a substance determines its boiling point.

4. Do stronger intermolecular forces result in higher or lower boiling points? HIGHER

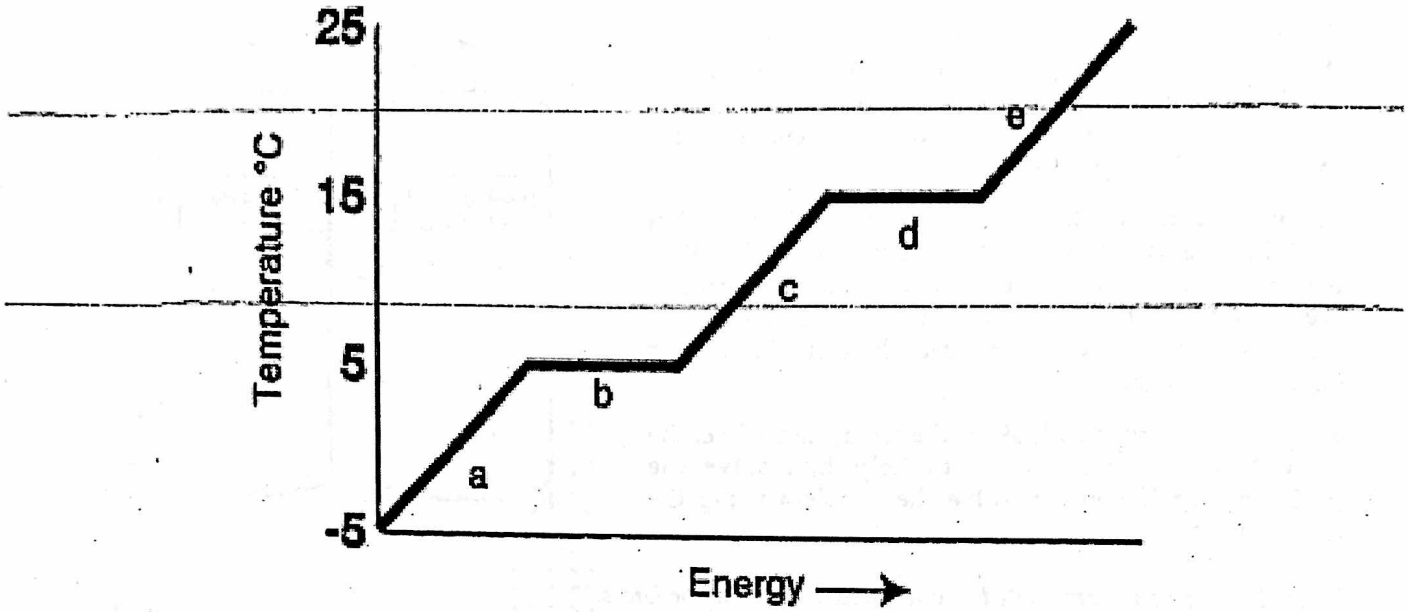
5. Which substance, F_2 or Cl_2, has the stronger intermolecular forces? Cl_2

6. a. What is the boiling point of F_2? $-188.1\,^{\circ}C$

   b. What is the boiling point of Cl_2? $-34.05\,^{\circ}C$

FREEZING AND BOILING POINT GRAPH

Name _____



Answer the following questions using the chart above.

1. What is the freezing point of the substance? b (5°C)
2. What is the boiling point of the substance? d (~15°C)
3. What is the melting point of the substance? b (5°C)
4. What letter represents the range where the solid is being warmed? a
5. What letter represents the range where the liquid is being warmed? c
6. What letter represents the range where the vapor is being warmed? e
7. What letter represents the melting of the solid? b
8. What letter represents the vaporization of the liquid? d
9. What letter(s) shows a change in potential energy? b & d (OMIT) (OMIT)
10. What letter(s) shows a change in kinetic energy? a, c, e
11. What letter represents condensation? d
12. What letter represents crystallization? b

Heating/Cooling Curves Practice

1a) -115 °C

b) 89°C

c) Higher, substances boil when vapour pressure = atmospheric pressure. Therefore, If it boils at a higher temperature then at standard pressure the atmospheric pressure must be higher.

d) Weaker because it has lower M.P. and B.P.

e) Liquid

f) The whole time

g) The heat energy is going into breaking the interactions (IMF) between particles to change the phase from solid to liquid.

2) Will take more energy and therefore more time to heat. The M.P. and B.P. will remain the same!

3) Ask if you are unsure if yours is right.

4) The M.P. and B.P. would remain the same but the time of each heating and phase change interval would decrease. Ie. The graph would appear "squished" along the x-axis

5) Same result as question 4 as more heat is being added to the system (assuming open system).