Ch. 11 Day 2
20 November 2019

Calculate ΔH°_{rxn} and ΔS°_{rxn} for...

	$C_2H_2 (g)$	+ $Cl_2 (g)$	→ $C (s)$	+ $2 HCl (aq)$	
ΔH°_f	$-166 \frac{kJ}{mol}$	$0 \frac{kJ}{mol}$	$0 \frac{kJ}{mol}$	$-167 \frac{kJ}{mol}$	$\Delta H^\circ_{rxn} = -168\ kJ$
	x −1 mol	x −1 mol	x +1 mol	x +2 mol	$\Delta H^\circ_{rxn} = \frac{-168\ kJ}{mol\ rxn}$
	+166 kJ	+ 0 kJ	+ 0 kJ	− 334 kJ	= −168 kJ ; $\Delta H^\circ_{rxn} = \frac{-168\ kJ}{2\ mol\ HCl}$
absolute entropy S° (all +!)	$264 \frac{J}{mol\ K}$	$223\ J/mol\ K$	$5.7 \frac{J}{mol\ K}$	$56.5 \frac{J}{mol\ K}$	$S^\circ_{gas} >> S^\circ_{liquid, sol'n} > S^\circ_{solid}$
	x −1 mol	x −1 mol	x +1 mol	x +2 mol	
ΔS°_{rxn} =	−264 J/K	−223 J/K	5.7 J/K	113 J/K	→ $\Delta S^\circ_{rxn} = -368\ J/K$

	favored	not favored
enthalpy	$\Delta H < 0$ exothermic "is heat given off?"	$\Delta H > 0$ endothermic "does it take heat?"
entropy (chaos!)	$\Delta S > 0$ entropy favored "is there an increase in disorder?" "is there an increase in the mols of gas?"	Example $\Delta n_{gas} = n^{gas}_{prod} - n^{gas}_{react}$ = 0 − 2 mol Δn_{gas} = −2 mol gas if $\Delta n_{gas} < 0$ $\Delta S < 0$ entropy − not favored

free energy → $\Delta G = \Delta H - T\Delta S$ (T → kelvin)

if $\Delta G < 0$ spontaneous, rxn can/will occur → "can/will this happen?"
$\Delta G > 0$ non-spontaneous

$NaCl (s) \rightarrow Na (s) + \frac{1}{2} Cl_2 (g)$ @ 25°C

$\Delta G = -168\ kJ - 298\ K \cdot \left(-\frac{0.368\ kJ}{K}\right) = -58.3\ kJ$ spontaneous!

$2C_2H_5OH (l) + 7O_2 (g) \rightarrow 4CO_2 (g) + 6H_2O (g)$ — combust!! $\Delta H < 0$; count gas! $\Delta S > 0$

phase change (ΔH & ΔS always same sign) | $\Delta G = \Delta H - T\Delta S$ always be (−) = (−) − (+)(+)

$H_2O (l) \rightarrow H_2O (g)$ $\Delta H > 0$ $\Delta S > 0$

$H_2O (l) \rightarrow H_2O (s)$ $\Delta H < 0$ (make bonds) $\Delta S < 0$

Does $H_2O (l) \rightarrow H_2O (g)$ @ 25°C? no! — spontaneous? ΔG

@ 125°C? yes!

@ bp (T_b) $\Delta G = 0$ — @ any phase change $\Delta G = 0$

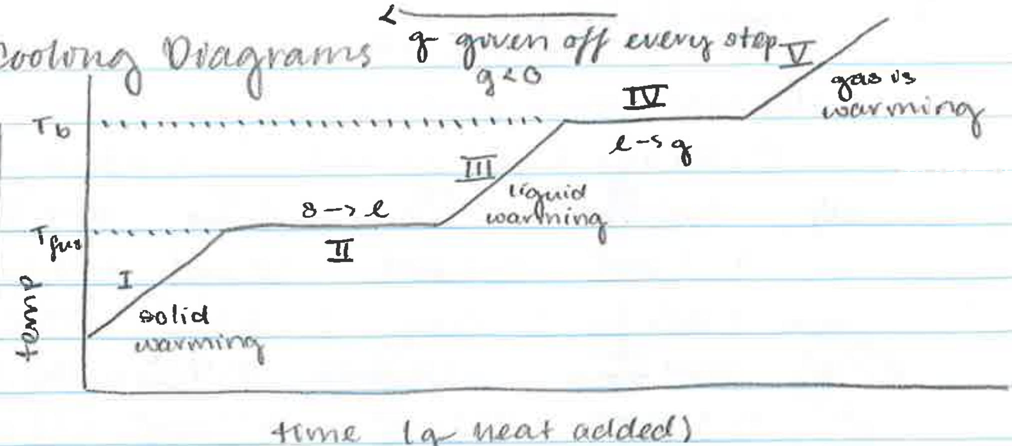
@ bp $\Delta G = \Delta H - T\Delta S$ — temperature insensitive; temperature dependant

$0 = \Delta H - T\Delta S \rightarrow T_b = \frac{\Delta H^\circ_{vap}}{\Delta S^\circ_{vap}} = \frac{+44.06\ kJ/mol\ H_2O}{0.1188\ kJ/mol\ H_2O} \Rightarrow 371\ K$ / 98°C

$q > 0$
q added for every step →

← q given off every step
$q < 0$

Heating & Cooling Diagrams



$q_I = C_{ice} \cdot n \cdot \Delta T$ ← $T_f - T_i$

$= \frac{36.7\ J}{mol\ deg} \cdot n \cdot (0°C - T_i)$ ← <0 ; (+)

$C = \frac{J}{g\ deg}$ $\quad q = C \cdot m \cdot \Delta T$

$q_{III} = C_{liq} \cdot n \cdot \Delta T$ ← for liquid region only

$= \frac{75.4\ J}{mol\ deg}$

$q_V = C_{gas} \cdot n \cdot \Delta T_{gas}$

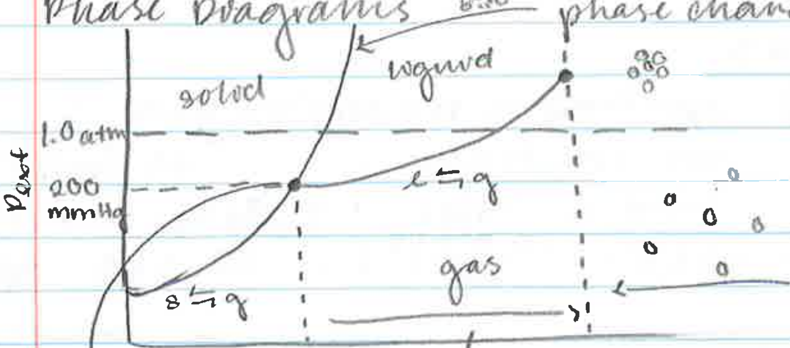
phase change parts, II & IV

$q_{II} = \Delta H°_{fus} \cdot n = (\frac{kJ}{mol})(mol) =$ ___ kJ

$q_{IV} = \Delta H°_{vap} \cdot n$

Phase Diagrams

phase change equilibrium $s \rightleftharpoons l$



permanent gases $T_b < T_c$

N_2, O_2, Ar
H_2, He

triple point
s & l & g

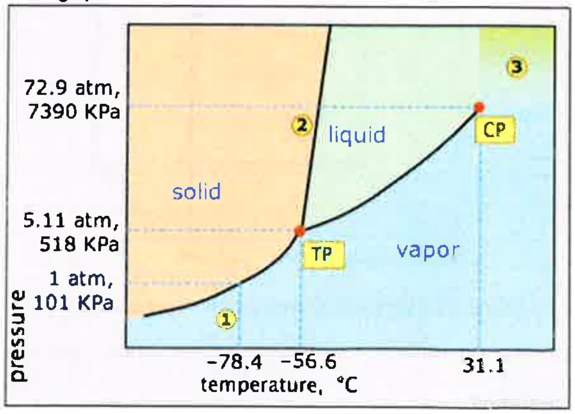
T_c, critical temp.
enough energy for no IMF

condensible gas

gas leaves
liquid evaporates

Chapter 11-12 Day 2 (Sections 11.5, 12.1, 12.3) 20 November 2019

1. Consider the phase diagram for CO_2 to answer the following questions.



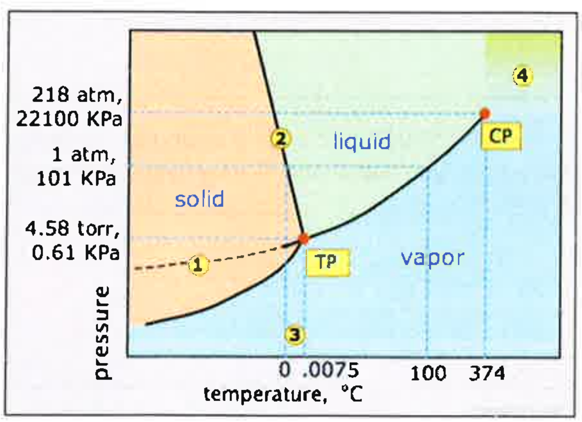
1a. What is the phase of CO_2 at 1 atm and -80 ^oC?

1b. What phase change, if any, occurs if CO_2 at 1 atm and 0 ^oC is compressed to a pressure of 50 atm?

1c. What phase equilibrium exists along the line between the blue region and the green region? Write out the answer with a chemical equation.

1d. Is CO_2 a condensable gas at room temperature?

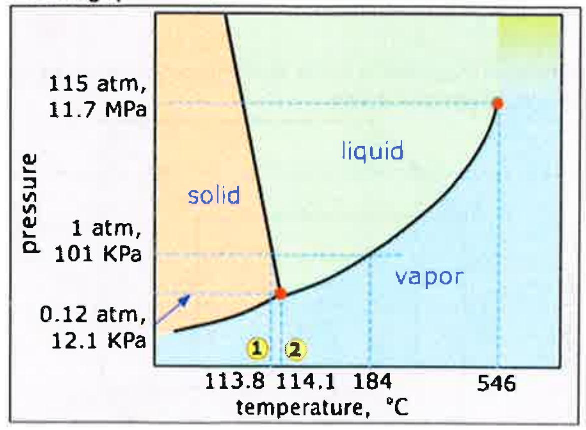
2. Consider the phase diagram for H_2O to answer the following questions.



2a. What phase change happens to H_2O at 1 atm and -10 ^oC if the pressure is increased?

2b. What phase change happens to H_2O at 1 atm and -10 ^oC if the temperature is increased to 110 ^oC?

3. Consider the phase diagram for I_2 to answer the following questions.

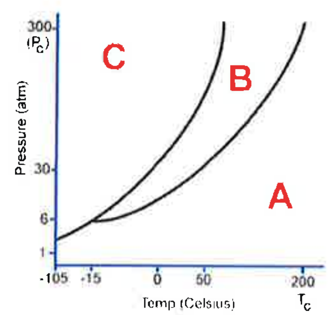


3a. What is the phase of I_2 at 1 atm and 25 ^oC?

3b. What line represents sublimation? Answer: The line between the colored regions ___ and ___.

3c. Which of the three substances investigated so far in this worksheet, CO_2, H_2O or I_2 has the highest critical temperature?

4. Use the phase diagram here to answer the following questions.



4a. What phase is this substance under standard conditions? Circle: SOLID or LIQUID or GAS

4b. This substance is a solid at:

A. 30 atm, -50 ^oC

B. 30 atm, +50 ^oC

C. 30 atm, +25 ^oC

D. 300 atm, 250 ^oC

4c. Circle the triple point.

4d. Draw an arrow pointing to the solid-liquid interface.

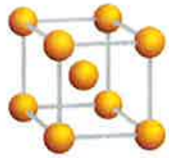
4e. What is the critical temperature?

4f. Is the solid phase more dense than the liquid phase? Circle: YES or NO

5. Classify each of these solids as covalent-molecular (CM), covalent-network (CN), metallic (M) or ionic (I)

A. ice	CM CN M I
B. graphite	CM CN M I
C. buckyball	CM CN M I
D. zinc	CM CN M I
E. potassium permanganate	CM CN M I
F. silicon carbide	CM CN M I
G. diamond	CM CN M I

6. Identify the unit cell shown here.

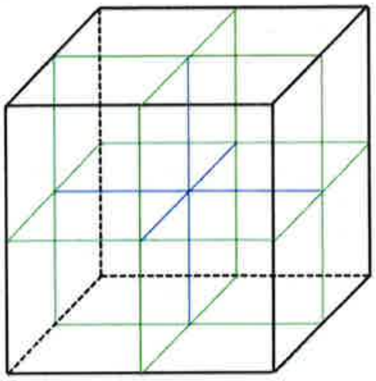


A. Simple cubic

B. Body-centered cubic

C. Face-centered cubic

7a. Sketch in circles to show the loaction of metal atoms in a simple cubic unit cell.



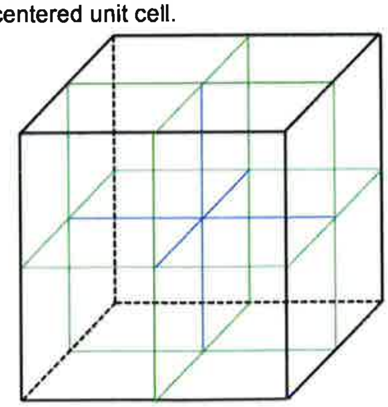
7b. How many corners are there?

7c. What fraction of each corner in within the unit cell? Choices: All of it, ½ of it, $^{1}/_{3}$, ¼ , $^{1}/_{8}$, or other:_______

7d. How many net corner atoms are within each unit cell?

7e. The simple cubic unit cell is not used by many metals. Polonium is one example of a metal that does utilize this structure. How many net polonium atoms are within each unit cell?

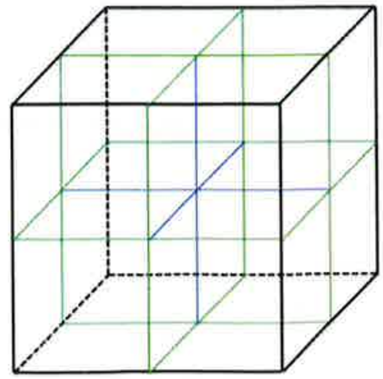
8a. Sketch in circles to show the loaction of metal atoms in a body-centered unit cell.



8b. What fraction of body-centered atom is entirely within the unit cell? Choices: All of it, ½ of it, $^{1}/_{3}$, ¼ , $^{1}/_{8}$, or other:_______

8c. How many net atoms in total are *within* each unit cell?

9a. Sketch in circles to show the loaction of metal atoms in a face-centered unit cell. Use one color to show the corner atoms and another color to show the locations of the face-centered atoms.

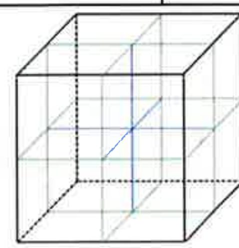


9b. Is there an atom at the body-centered position?

9c. What fraction of each face-centered atom is entirely within the unit cell? Choices: All of it, ½ of it, $^{1}/_{3}$, ¼ , $^{1}/_{8}$, or other:_______

9d. How many net atoms in total are *within* each unit cell?

10a. Lead crystallizes in a fcc unit cell with an edge length of 495 pm. What is the atomic radius of lead in pm?



10b. What is the density of lead using the information from Problem 2?

10c. Sodium crystallizes in a body-centered unit cell and has a density of 0.968 g/cm^3. What is the atomic radius of sodium?

In the next lecture we will encounter ionic substances and learn that the larger ion, usually the anion, can occupy the same locations as these metal atoms you have sketched here. The smaller ions, usually the cations, will occupy specific holes created by the bigger ions.

Now try these problems from the book:

Section 11.5. (Phase diagrams) Problems 7, 8, 16, 52 – 66 (even)

Section 12.1 (Types of Solids) 26 – 30, even.

Section 12.3. (Unit cells) Problem 1 – 4, 34 – 48 even.