Recitation Worksheet 2: Solids (10.3-10.4 and 10.6-10.7)

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, February 3rd at 11:59 pm. Write your work on separate sheets of paper, convert to a PDF and upload to the "Recitation Worksheet 2 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, February 3rd 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. Classify the following solids as either:

   A. Molecular solid
   B. Metallic solid
   C. Ionic solid
   D. Network covalent solid

   For your answer insert one of the choices A – D in the answer box. Example, if the answer is metallic, then the answer is choice B.

   C — A. $Ca_3(PO_4)_2$ An ionic compound forms as a result of electrostatic interaction between an a cation (Ca^{2+}) and an anion (in this case it is a polyatomic anion PO_4^{3-})

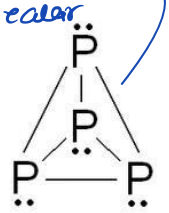
   B — B. Fe only one type of atom & Fe is a transition metal

A

C. P_4 (hint: melting point 44.1 °C)

covalent bonds exist between phosphorous atoms but LDFs exist between P_4 atoms ∴ it is a molecular solid

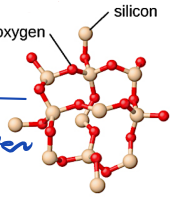
the low melting point might be an indication that P_4 is a molecular solid



D

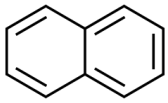
D. SiO_2

silicon dioxide is a 3D network of silicon atoms bonded to oxygen atoms



A

E. Naphthalene ($C_{10}H_8$)

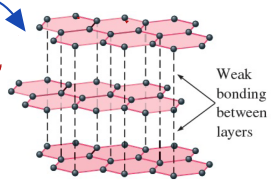


LDF is found between naphthalene molecules

D

F. C (*s*, graphite)

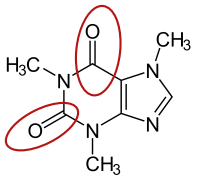
graphite is a layered structure. within the layers each carbon atom is covalently bonded to three other carbon atoms. the layers are held together by dispersion forces.



A

G. Caffeine ($C_8H_{10}N_4O_2$)

Caffeine is capable of forming dipole-dipole forces with another caffeine molecule



2. Covalent bonding occurs in both molecular and covalent network solids. Which of these statements best explains why these two kinds of solids differ so greatly in their hardness and melting points?

B

A. The molecules in molecular solids have stronger covalent bonding than covalent-network solids do.

B. The molecules in molecular solids are held together by weak intermolecular interactions.

C. The atoms in covalent-network solids are more polarizable than those on molecular solids.

D. Molecular solids are denser than covalent network solids.

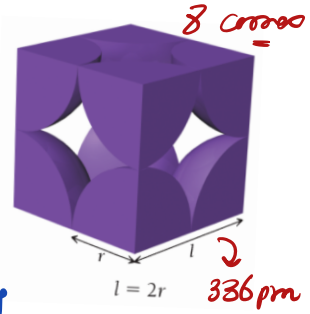
* Covalent network solids are composed entirely of a 3D network of covalently bonded atoms
* Molecular solids have strong covalent bonds within the molecule but weaker intermolecular forces between molecules

3. Polonium crystallizes in a simple cubic cell unit. If the edge length of the unit cell is 336 pm, calculate the density of polonium in g/cm^3. (1 cm = 1 x 10 ^{10} pm, molar mass of Po = 209 g/mol). Keep your answers to 3 sig figs.

9.15 g/cm^3

1 pm = 1×10^{-10} cm

Density = mass / volume



① To calculate the volume

$336 \text{ pm} \times \frac{1 \text{ cm}}{1 \times 10^{10} \text{ pm}} = 3.36 \times 10^{-8} \text{ cm}$

$V = l^3 = (3.36 \times 10^{-8})^3$

$= 3.79\,33056 \times 10^{-23} \text{ cm}^3$

② To calculate the mass

$1 \text{ atom} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} \times \frac{209 \text{ g Po}}{1 \text{ mol Po}} = 3.47060\,777 \times 10^{-22} \text{ g}$

③ Calculate density

$\text{Density} = \frac{3.47060\,777 \times 10^{-22} \text{ g}}{3.79\,33056 \times 10^{-23} \text{ cm}^3}$

$= 9.15 \text{ g/cm}^3$

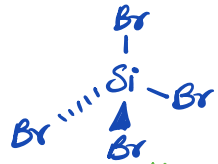
4. In the following solid pairs, which substance has the **higher** melting point?

A. Pd or HOOH — Pd

Pd is a transition metal ∴ has metallic bonds while H_2O_2 is a molecular compound & only has intermolecular forces between its molecules

B. $SiCl_4$ or $SiBr_4$ — $SiBr_4$

molar mass = 169.9 g/mol



molar mass = 347.7 g/mol

larger ↑ molecule ∴ stronger dispersion forces

Both compounds have a tetrahedral symmetrical molecular geometry ∴ the only type of IMF that exists in both compounds is dispersion forces

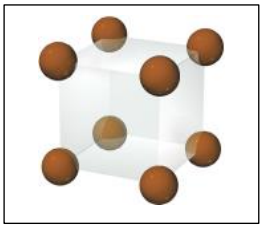
C. KF or HF — KF

ionic compound vs. a molecular compound

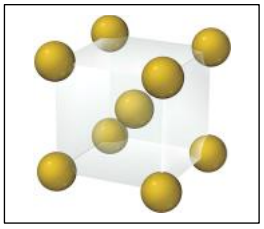
D. C (*s*, diamond) or K — C(diamond)

Diamond is a network covalent compound ∴ has a higher melting than potassium which is a metallic compound

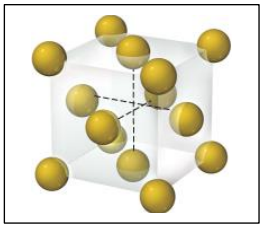
5. Nickel is a hard silver-white metal which occurs as face-centered cubic crystal, while polonium is a radioactive metal that occurs as a simple cubic crystal, and tungsten is a rare earth metal that occurs as a body-centered cubic crystal. Examine the images A – C below and answer the following questions:



A



B



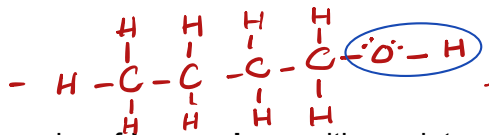
C

I. Tungsten metal crystal unit cell is (choose one of images A – C) — B

II. Nickel has — 4 — atoms in its unit cell (insert numerical value, example: 1, 2, 3, etc.)

III. The coordination number of unit cell in a polonium crystal is — 6 — (insert numerical value, example: 1, 2, 3, etc.)

IV. Image C matches the description for — Ni — (Choose either Ni, W, or Po. Write the chemical symbol in the answer box and NOT the full name of the element).



oxygen is covalently bonded to hydrogen ∴ has the ability to form H-bonds.

6. Arrange the solid compounds below in order of **increasing** melting points.

$Ar(s)$, $CCl_4(s)$, $LiCl(s)$, $C_4H_9OH(s)$

C_4H_9OH

Ar is a gas at room temperature & when it solidifies Ar molecules are connected by london dispersion force

B	A. $LiCl(s) < C_4H_9OH(s) < CCl_4(s) < Ar(s)$
	B. $Ar(s) < CCl_4(s) < C_4H_9OH(s) < LiCl(s)$
	C. $CCl_4(s) < LiCl(s) < Ar(s) < C_4H_9OH(s)$
	D. $C_4H_9OH(s) < LiCl(s) < CCl_4(s) < Ar(s)$
	E. $Ar(s) < C_4H_9OH(s) < CCl_4(s) < LiCl(s)$

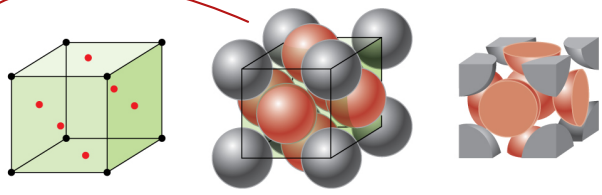
has a tetrahedral symmetrical molecular structure ∴ non-polar

It is a liquid at room temperature & CCl_4 molecules will be brought together by london dispersion force

- LiCl is an ionic compound. the cation & anion are connected via ionic bonding (intra-molecular force) stronger than IMFs ∴ highest melting point

7. Nickel has a face-centered cubic structure and has a density of 8.90 g/cm^3. What is the volume of the unit cell in cm^3? Report your answer to 3 sig figs and use scientific notation. (Molar mass of nickel = 58.69 g/mol).

4.38 X 10 $^{-23}$ cm^3



Face-centered cubic structure

A face-centered cubic unit cell has an atom in each corner of the cube (an atom in the corner is 1/8 of an atom) & an atom in each face of the cube (an atom in the face is 1/2 atom)

Total # of atoms = $(8 \times \frac{1}{8}) + (6 \times \frac{1}{2}) = 4$ atoms

① Find the mass of one nickel atom

$$4 \text{ atom} \times \frac{1 \text{ mol Ni}}{6.022 \times 10^{23} \text{ atoms}} \times \frac{58.69 \text{ g Ni}}{\text{mol}} = 3.89837268 \times 10^{-22} \text{ g}$$

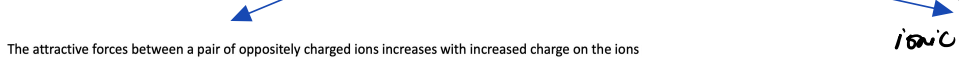
② Calculate the mass of the unit cell

using density: $\frac{1 \text{ cm}^3}{8.90 \text{ g}} \times 3.89837268 \times 10^{-22} \text{ g} = 4.38 \times 10^{-23} \text{ cm}^3$

8. You are given a set of ions: Na^+, K^+, Ca^{2+}, Mg^{2+}, F^-, Br^-, O^{2-}, and S^{2-}. Which cation and which anion do you expect to combine to form the highest melting ionic compound? Insert your answer as a formula, example **NaCl**.

MgO

- to make predictions which ionic solid may have the highest melting point you should consider Lattice energy
- two factors influence the magnitude of lattice energy



The attractive forces between a pair of oppositely charged ions increases with increased charge on the ions

the smaller the ionic size the greater the the greater the magnitude of lattice energy

ionic size

Between the two factors ionic charge is more important ∴ you can narrow down your choices to Ca^{2+} & Mg^{2+} cations and O^{2-} & S^{2-} anions

↓

Since the magnitude of charges is equivalent in this case you have to make a choice based off of ionic size

$Mg^{2+} < Ca^{2+}$ & $O^{2-} < S^{2-}$ in atomic size

9. A diamond unit cell has a volume of 0.0454 nm^3. If the density of diamond is 3.52 g/cm^3, how many carbon atoms are in a unit cell of diamond? (1 cm = 1 x 10^7 nm, molar mass of carbon = 12.01 g/mol).

E

A. 11 atoms
B. 20 atoms
C. 10 atoms
D. 14 atoms
E. 8 atoms

① Find the mass of a diamond unit cell

$$3.52\ \frac{g}{cm^3} \times \left(\frac{1cm}{1\times10^7 nm}\right)^3 \times 0.0454\ nm^3 = 1.59808\times10^{-22}\ g$$

② Find the number of carbon atoms in one unit cell

$$1.59808\times10^{-22}\ g \times \frac{1\ mol\ C}{12.01\ g\ C} \times \frac{6.022\times10^{23}\ atoms}{1\ mol\ C}$$

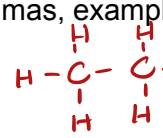
$$= 8.013020616$$

$$\sim 8\ atoms$$

10. Among the options shown, which chemical formula is paired with an **incorrect** crystal type? Select all that apply. Insert letters without spaces or commas, example: **ABCD**.

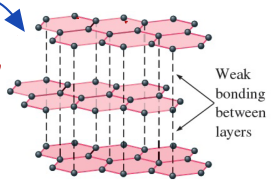
BC

A. I_2, Molecular LDF
B. C_2H_6, Covalent Network
C. C (graphite), Molecular
D. NaF, Ionic
E. Cu, Metallic



(non-polar molecule ∴ LDF)

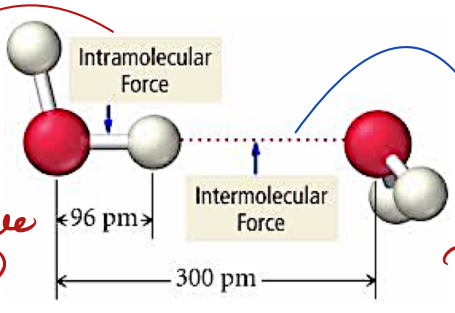
Graphite is a layered structure. Within the layers each carbon atom is covalently bonded to three other carbon atoms. The layers are held together by dispersion forces.



11. Which of these statements is **false**?

E

A. Molecular solids generally have lower melting points than covalent solids. True
B. Metallic solids exhibit a wide range of melting points because metallic bonds cover a wide range of bond strength. True
C. The metallic solid can be viewed as positive ions closely packed in a sea of valence electrons. True
D. Most molecular solids melt at lower temperatures than metallic solids. True
E. The interactions among the molecules in molecular solids are generally stronger than those among the particles that define either covalent or ionic crystal lattices. False



Intramolecular forces between atoms within a molecule (ex: covalent & ionic) are true bonds are very strong compared to intermolecular forces

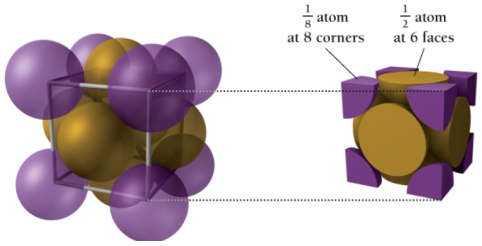
Intermolecular force is a weak electrostatic interaction (found in molecular solids) & they are weaker compared to intramolecular forces

12. Which statement is true regarding the different types of cubic unit cells? Select all that apply. Insert letters without spaces or commas, example**: ABCD**.

BD

A. Simple cubic unit cell has two atoms per unit cell whereas body centered cubic unit cell has four atoms per unit cell
B. A fraction of a corner sharing atom is 1/8 in face centered cubic unit cell
C. The coordination number for body centered cubic is 12
D. A fraction of face sharing atom is 1/2 in face centered cubic unit cell
E. None of these statements are true

one atom
has two atoms
False
True
coordination number is 8
True



13. Which of these ionic solids has the **highest** melting point?

E

A. CaF_2
B. KCl
C. LiCl
D. NaCl
E. MgS

Please refer to question 8 for further explanation