Recitation Worksheet (Optional Extra Practice)

Name: Key

MyID:

Textbook:

Chemistry & Chemical Reactivity
by John C. Kotz, Paul M. Treichel, John R. Townsend, David Treichel
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Instructions:

- This recitation worksheet is optional extra practice for 12.1-12.3, 12.5 and 14.1-14.4.
- You **do not** need to submit it to Gradescope.
- The answer key has been posted with this worksheet to eLC.
- A periodic table and formula sheet are attached to the end of this worksheet.

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

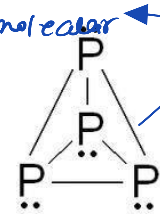
A. $Ca_3(PO_4)_2$ An ionic compound forms as a result of electrostatic interaction between an a cation (Ca^{2+}) and an anion (in this case it is a polyatomic anion PO_4^{3-})

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

A

B. P_4 (hint: melting point 44.1 °C)

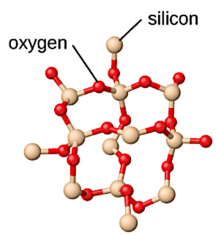
the low melting point might be an indication that P_4 is a molecular solid



D

C. SiO_2

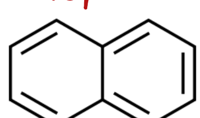
silicon dioxide is a 3D network of silicon atoms bonded to oxygen atoms



A

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

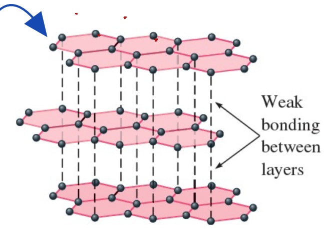
LDF is found between naphthalene molecules



D

E. C (*s*, graphite)

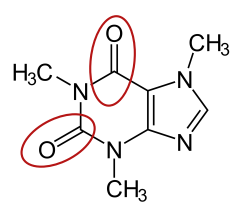
Graphite is a layered structure. within the layers each carbon atom is covalently bonded to three other carbon atoms. the layers are held together by dispersion forces.



A

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

Caffiene is capable of forming dipole-dipole forces with another caffiene molecule



B

G. Fe

only one type of atom & Fe is a transition metal

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 so

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

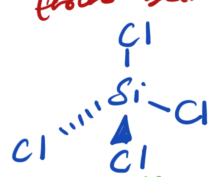
3. In the following solid pairs, which substance has the **higher** melting point?

A. Pd or HOOH — Pd

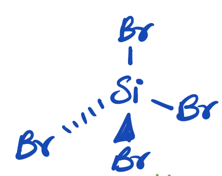
Pd is a transition metal ∴ has metallic bonds while H_2O_2 is a molecular compound & only has intermolecular forces between its molecules

B. $SiCl_4$ or $SiBr_4$ — $SiBr_4$

larger molecule ∴ stronger dispersion forces



molar mass = 169.9 g/mol



molar mass = 347.7 g/mol

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

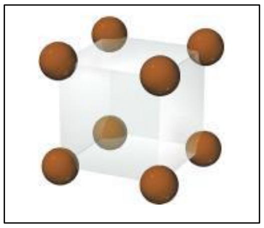
C. KF or HF — KF

ionic compound vs. a molecular compound

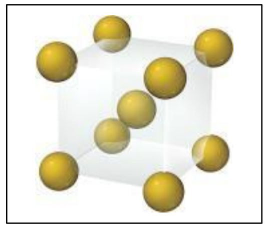
D. C (*s*, diamond) or K — C(diamond)

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

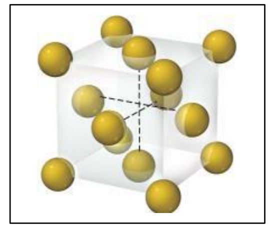
4. Nickel is a hard silver-white metal which occurs as face-centered cubic crystal, while polonium is a radioactive metal that occurs as a simple cubic crystal, and tungsten is a rare earth metal that occurs as a body-centered cubic crystal. Examine the images A – C below and answer the following questions:



A



B



C

I. Tungsten metal crystal unit cell is (choose one of images A – C) $\boxed{B}$

II. Nickel has $\boxed{4}$ 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 $\boxed{6}$ (insert numerical value, example: 1, 2, 3, etc.)

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

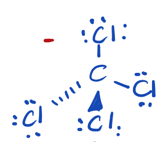
5. Arrange the solid compounds below in order of **increasing** melting points.

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

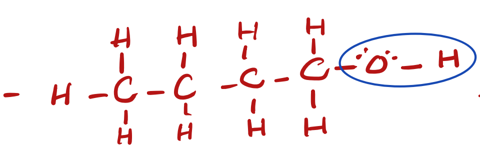
$\boxed{B}$

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*)

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

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

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

6. 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**.

$\boxed{MgO}$

- 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 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 b off of ionic size

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

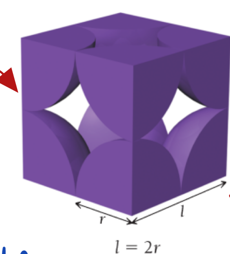
7. Polonium crystallizes in a simple cubic cell unit. If the edge length of the unit cell is 336 pm, calculate the density of polonium in g/cm^3. (1 cm = 1 x 10^{10} pm, molar mass of Po = 209 g/mol).

$\boxed{9.15}$ g/cm^3

$1\,pm = 1\times10^{-10}\,cm$

$Density = \dfrac{mass}{Volume}$

8 corners



Simple cubic unit cell

336 pm

1 to calculate the volume

$336\,\cancel{pm} \times \dfrac{1\,cm}{1\times10^{10}\,\cancel{pm}} = 3.36\times10^{-8}\,cm$

$V = l^3 = (3.36\times10^{-8})^3$

$= 3.7933056\times10^{-23}\,cm^3$

3 Calculate density

$Density = \dfrac{3.47060777\times10^{-22}\,g}{3.7933056\times10^{-23}\,cm^3}$

$= 9.15\,g/cm^3$

2 To calculate the mass

$1\,\cancel{atom} \times \dfrac{1\,\cancel{mol}}{6.022\times10^{23}\,\cancel{atoms}} \times \dfrac{209\,g\,Po}{\cancel{mol\,Po}} = 3.47060777\times10^{-22}\,g$

8. 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).

$\boxed{E}$

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

1 Find the mass of a diamond unit cell

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

2 Find the number of Carbon atoms in one unit cell

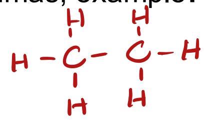
$1.59808\times10^{-22}\,\cancel{g} \times \dfrac{1\,\cancel{mol\,C}}{12.01\,\cancel{g\,C}} \times \dfrac{6.022\times10^{23}\,atoms}{1\,\cancel{mol\,C}}$

$= 8.013020616 \sim 8$ atoms

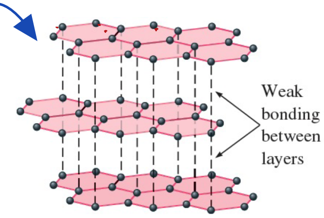
9. Among the options shown, which chemical formula is paired with an **incorrect** crystal type? Select all that apply. Insert letters without spaces or commas, example**: ABCD**.

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.

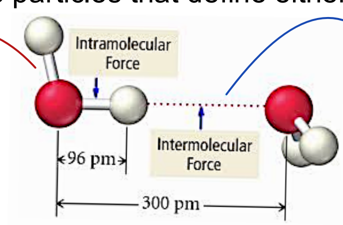


10. Which of these statements is **false**?

E

A. Molecular solids generally have lower melting points than covalent solids.
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.
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 with a molecule (ex: covalent & ionic) are true bonds are very strong compared to intermolecular forces



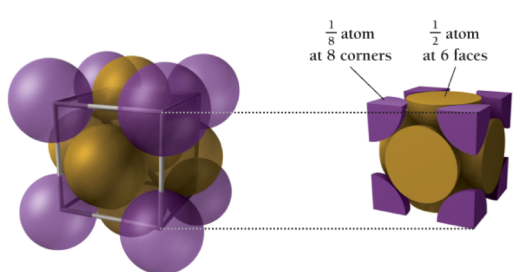
Intermolecular force is a weak electrostatic interaction (found in molecular solids) & they are weaker compared to intramolecular forces

11. 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

one atom / has two atoms

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



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

$\boxed{\text{E}}$

A. CaF_2
B. KCl
C. LiCl
D. NaCl
E. MgF_2

Please refer to question 6 for further explanation

13. You are provided with an unknown solid and you inspect its physical properties to find that it has a melting point of 1127 °C, soluble in water, does not conduct heat or electricity as a solid, and is very hard. Given these properties, which of the following choices matches the physical properties of the unknown substance?

$\boxed{\text{A}}$

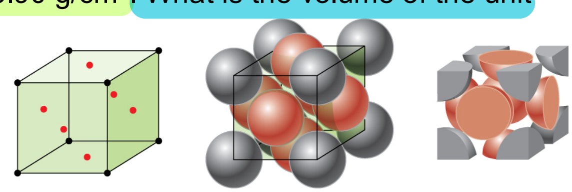
A. CoF_2
~~B.~~ CO_2
~~C.~~ Li
~~D.~~ C (s, diamond)
~~E.~~ SiO_2
~~F.~~ $CHCl_3$

- Choices B & F: CO_2 & $CHCl_3$ can form molecular solids which have a very low melting point
- Choices D & E: diamond & silicon dioxide are both covalent network solids and they are insoluble in water
- choice C: Li is a metallic solid (metallic solids have variable melting points but lower in comparison to ionic & network covalent solids).

14. Nickel has a face-centered cubic structure and has a density of 8.90 g/cm³. What is the volume of the unit cell in cm³?

$\boxed{4.38}$ X 10 $\boxed{-23}$ cm³

A face-centered cubic unit cell has an atom in each corner of the cube



Face-centered cubic structure

(an atom in the corner is 1/8 of an atom) & an atom on each face of the cube (an atom on the face is $\frac{1}{2}$ atom)

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

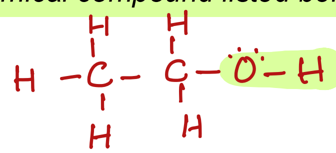
① Find the mass of one nickel atom

$$4 \text{ atom} \times \frac{1 \text{ mol Ni}}{6.022\times10^{23} \text{ atoms}} \times \frac{58.69 \text{ g Ni}}{\text{mol}} = 3.89837263\times10^{-22} \text{ g}$$

② Calculate the mass of the unit cell

using density: $$\frac{1 \text{ cm}^3}{8.90 \cancel{\text{g}}} \times 3.89837263\times10^{-22} \cancel{\text{g}} = 4.38\times10^{-23} \text{ cm}^3$$

15. Classify each of the solids as A) covalent, B) ionic, C) metallic, or D) molecular solids. *The answer on your answer sheet should be a **letter** corresponding to the chemical compound listed below.*



capable of forming H-bond

I. Solid ethanol (CH_3CH_2OH) $\boxed{D}$

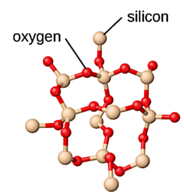
II. Sodium iodide NaI $\boxed{B}$

Na^+: metal cation I^-: non-metal anion
∴ both form an ionic compound

III. Pure potassium $\boxed{C}$

K is in group I (alkali metals)

IV. Silicon dioxide $\boxed{A}$



→ silicon dioxide (network solid)

16. Carbon monoxide is observed to melt at -205℃, whereas carbon dioxide sublimates at -78.5 °C. The absence of which IMF explains why carbon dioxide cannot become a liquid at atmospheric pressure?

$\boxed{C}$

$:\ddot{O}=C=\ddot{O}:$

↓

Linear molecular geometry
∴ non-polar molecule
∴ has only London dispersion forces

~~A.~~ London Dispersion Forces this is why it is either a gas or a solid

~~B.~~ Ion-Dipole forms between an ion (cation or anion) & a polar compound

C. Dipole-Dipole

~~D.~~ Hydrogen-Bonding → oxygen does not have a hydrogen atom covalently bonded to it

17. If gold crystallizes in a face-centered cubic arrangement and the edge length of the unit cell is 4.08 Å. What is the density of gold in g/cm³?

$\boxed{19.3}$ g/cm³

1 Å = 10^{-8} cm

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

① Mass of one Au atom =

$$\cancel{4 \text{ Au}} \text{ atoms} \times \frac{1 \text{ mol } \cancel{\text{Au}}}{6.022 \times 10^{23} \text{ mol } \cancel{\text{Au}}} \times \frac{196.97 \text{ g Au}}{1 \text{ mol } \cancel{\text{Au}}}$$

$$= 1.3083361 \times 10^{-21} \text{ g Au}$$

② Volume of Au unit cell

$$V = l^3 = (4.08 \text{ Å})^3 \times \left(\frac{10^{-8} \text{ cm}}{1 \text{ Å}}\right)^3 = 6.7917312 \times 10^{-23} \text{ cm}^3$$

③ $$\text{Density} = \frac{1.3083361 \times 10^{-21} \text{ g Au}}{6.7917312 \times 10^{-23} \text{ cm}^3} = 19.26366138 \text{ g/cm}^3$$

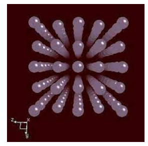
$$\approx 19.3 \text{ g/cm}^3$$

18. Classify each of the solids below as A) ionic solid, B) network covalent solid, C) metallic, or E) molecular solid

i. Barium chloride $\boxed{A}$

Ba^{2+}: alkaline earth metal cation Cl^-: non-metal anion

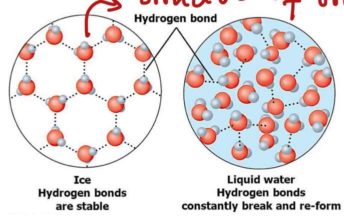
ii. Krypton $\boxed{E}$



krypton solid (Kr is an atom that forms LDFs with other Kr atoms in the solid)

iii. Ruthenium $\boxed{C}$

structure of snow

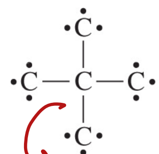


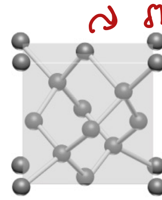
(the dotted lines represent hydrogen bonding)

iv. Snow $\boxed{E}$

v. C (Diamond) $\boxed{B}$

structure of diamond





sp^3 hybridized carbon

19. Which of the following statements regarding crystalline solids is **true**?

~~I.~~ Molecules or atoms in molecular solids are held together ~~via ionic bonds~~ intermolecular forces.

II. Metallic solids have atoms (cations) in the points of the crystal lattice.

~~III.~~ Ionic solids have ~~formula units~~ ions in the point of the crystal lattice.

~~IV.~~ ~~Molecules~~ Atoms in covalent-network solids are connected via a network of covalent bonds.

$\boxed{B}$

A. I
B. II
C. III
D. IV
E. None of the above statements are tru

20. For the reaction A + 2 B ⟶ 2 C, the rate of the reaction is 1.76×10^{-5} M/s at the time when [A] = 0.3580 M.

A. What is the rate of formation of C?

$\boxed{3.52 \times 10^{-2}}$ M/s

$$\text{Rate of the reaction} = +\frac{1}{2}\frac{\Delta[C]}{\Delta t}$$

$$1.76 \times 10^{-5} = +\frac{1}{2}\frac{\Delta[C]}{\Delta t}$$

$$\therefore \frac{\Delta[C]}{\Delta t} = 3.52 \times 10^{-2}\ M/s$$

B. What will [A] be 1.00 min later?

$\boxed{0.357}$ M

$$\text{Rate} = \frac{\Delta[A]}{\Delta t}$$

$$\therefore 1.76 \times 10^{-5} = \frac{0.3580 - [A]_{1.00}}{1.00\ \text{min} \times \frac{60\ \text{sec}}{1\ \text{min}}}$$

$$= 0.356944\ M \approx 0.357\ M$$

C. How long will it take for [A] to change from 0.3580 M to 0.3500 M assuming the rate remains at 1.76×10^{-5} M/s?

$\boxed{4.5 \times 10^{2}}$ s

$$\text{Rate} = \frac{\Delta[A]}{\Delta t}$$

$$\therefore -1.76 \times 10^{-5} = \frac{0.3500 - 0.3580}{\Delta t}$$

$$\therefore \Delta t = 4.54545454 \times 10^{2}\ \text{seconds}$$

$$\approx 4.5 \times 10^{2}\ \text{seconds}$$

21. The following data are obtained for the initial rates of the reaction in the reaction A + 2 B + C ⟶ 2 D + E.

Experiment	Initial [A]	Initial [B]	Initial [C]	Initial Rate
1	1.40	1.40	1.00	R1
2	0.70	1.40	1.00	R2 = $\frac{1}{2}$ x R1
3	0.70	0.70	1.00	R3 = $\frac{1}{4}$ x R2
4	1.40	1.40	0.50	R4 = 16 x R3
5	0.70	0.70	0.50	R5 = ?

A. What are the reaction orders with respect to A, B, and C?

$$\text{Rate} = K\,[A]^{\boxed{1}}\,[B]^{\boxed{2}}\,[C]^{\boxed{-1}}$$

$Rate = k[A]^x [B]^y [C]^z$

i) Using Experiments 1 & 2

$$\frac{\text{Rate Exp 2}}{\text{Rate Exp 1}} = \frac{k[A]_2^x [B]_2^y [C]_2^z}{k[A]_1^x [B]_1^y [C]_1^z}$$

$$\frac{\frac{1}{2} \times \cancel{R_1}}{\cancel{R_1}} = \frac{\cancel{k}[0.70]^x \cancel{[1.40]^y} \cancel{[1.00]^z}}{\cancel{k}[1.40]^x \cancel{[1.40]^y} \cancel{[1.00]^z}}$$

$$\frac{1}{2} = \left(\frac{0.7}{0.14}\right)^x \quad \therefore \frac{1}{2} = \left(\frac{1}{2}\right)^x$$

$\therefore x = 1$

) Using experiments 2 & 3

$$\frac{\frac{1}{4} \times R_2}{\frac{1}{2} \times R_1} = \frac{[0.70]\ [0.70]^y\ [1.00]^z}{[0.70]\ [1.40]^y\ [1.00]^z}$$

(contd)

$$\frac{\frac{1}{4} \times (\cancel{\frac{1}{2}R_1})}{\cancel{\frac{1}{2}(R_1)}} = \frac{[0.70]^y}{[1.40]^y}$$

$$\frac{1}{4} = \left(\frac{1}{2}\right)^y$$

$\therefore y = 2$

3) Using exp. 3 & 4

$$\frac{16 \times R_3}{\frac{1}{4} \times R_2} = \frac{[1.40][1.40]^2\ [0.50]^z}{[0.70]\ [0.70]^2\ [1.00]^z}$$

$$\frac{16 \times \cancel{\frac{1}{4} \times R_2}}{\cancel{\frac{1}{4} \times R_2}} = 8\left(\frac{1}{2}\right)^z$$

$$\therefore 2 = \left(\frac{1}{2}\right)^z$$

$\therefore z = -1$

B. What is the value of R5 in terms of R1? Express your answer for R5 as a fraction of R1.

$$R5 = \frac{\boxed{1}}{\boxed{4}} \text{ X R1}$$

Using experiments 1 & 5

$$\frac{R5}{R1} = \frac{\cancel{k}[0.70][0.70]^2[0.50]^{-1}}{\cancel{k}[1.40][1.40]^2[1.00]^{-1}}$$

$$\frac{R5}{R_1} = \frac{1}{4}$$

$4 \times R_5 = R_1$

$\therefore R_5 = \frac{1}{4} \times R_1$

22. If a reaction is first order with a rate constant of $5.48 \times 10^{-2}\ s^{-1}$, how long is required for 3/4 of the initial concentration of reactant to be used up?

$\boxed{A}$

A. 25.3 s
B. 36.5 s
C. 6.3 s
D. 18.2 s
E. 50.6 s

For a first order process:

$\ln[A]_t = -kt + \ln[A]_0$

Initial conc if not given it will be always 1 or a 100

concentration remaining at the end of the reaction

$\ln\left[\frac{1}{4}\right] = -5.48 \times 10^{-2}(t) + \ln[1]$

remaining

$1 - \frac{3}{4}$

initial conc

used up

$\therefore t = 25.297342856$ seconds

$\approx 25.3\ s$

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 $kg \cdot m^2/s^2$
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 $kg/m \cdot s^2$
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
c = 2.998×10^8 m/sec
h = 6.626×10^{-34} $J \cdot sec^{-1}$
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: 9.109×10^{-31} kg
Mass of a proton: 1.673×10^{-27} kg
RH = 2.18×10^{-18} J
Specific heat of water = 4.184 J/g·K
STP = 273.15 K and 1 atm
Avogadro's number: 6.022×10^{23}

Equations
d (density) = m/V
$P_1V_1=P_2V_2$
$V_1/T_1=V_2/T_2$
$P_1V_1/n_1T_1=P_2V_2/n_2T_2$
$PV=nRT$
$(P + a(n^2/V^2))\cdot(V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT
$x_A = n_A/n_{tot} = P_A/P_{tot} = V_A/V_{tot}$
$P_{tot} = P_A + P_B + \ldots$
$n_{tot} = n_A + n_B + \ldots$
$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$Q = C \times \Delta T = c_{specific} \times m \times \Delta T$
$Q = n \times \Delta H$ (kJ/mol) $= m \times \Delta H$ (kJ/g)
$w = -P\Delta V$
$\Delta E = q + w$
$\Delta H° = \Sigma n\Delta Hf°(\text{products}) - \Sigma n\Delta Hf°(\text{reactants})$
$\Delta H° = \Sigma n\Delta H°(\text{bonds broken}) - \Sigma n\Delta H°(\text{bonds formed})$
$E=h\nu$
$c=\lambda\nu$
$\lambda = h/mv$

$$\Delta E = -2.18 \times 10^{-18} J(\frac{1}{n_f^2} - \frac{1}{n_i^2})$$

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

$C_g = kP_g$
$P_{solution}=P_{solvent}\,X_{solvent}$
$P_{solution}=\sum P_j=\sum P_jX_j$
$\Delta T_b = K_b m i$
$\Delta T_f = K_f m i$
$\pi = MRTi$

Thermodynamic and Electrochemistry

$S = k_b \times \ln(W)$
$k_b = 1.381 \times 10^{-23}$ J/K
$\Delta S = q_{rev}/T$
$\Delta S_{surr} = q_{surr}/T = -q_{rev}/T$
$\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$
$\Delta S°_{rxn} = \Sigma \nu S°_{products} - \Sigma \nu S°_{reactants}$
$\Delta H°_{rxn} = \Sigma \nu H°_{products} - \Sigma \nu H°_{reactants}$
$\Delta G°_{rxn} = \Sigma \nu G°_{products} - \Sigma \nu G°_{reactants}$
$\Delta G = \Delta H - T\Delta S$
$\Delta G = \Delta G° + RT \cdot \ln Q$
$R=8.314$ J/mol.K
$\Delta G° = -RT \cdot \ln K$
$\Delta G = -nFE_{cell}$
$F = 96485$ J/(V·mol e^-)
$E°_{cell} = RT/nF \ln K$
$E°_{cell} = (0.0257/n) \ln K = (0.0592/n) \log K$
$E_{cell} = E°_{cell} - (RT/nF) \ln Q$
$E_{cell} = E°_{cell} - (0.0257/n) \ln Q$
Electrolysis: Q (total charge) = $I \times t = n \times F$

Integrated Rate Laws & half-life

$$\ln\frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln\frac{k_2}{k_1} = -\frac{\mathrm{E_a}}{\mathrm{R}}(\frac{1}{\mathrm{T_2}} - \frac{1}{\mathrm{T_1}})$$

Equilibrium and Acid / Base

$K_P = K_c \times (RT)^{\Delta n}$
pH = $-\log[H_3O^+]$
$K_w = 1.0 \times 10^{-14}$ at 25 °C
$K_w = [H_3O^+] \times [OH^-]$
$K_w = K_a \times K_b$
$pK_a = -\log[K_a]$
Buffer: pH = $pK_a + \log\frac{[A^-]}{[HA]}$

$$ln\frac{K_2}{K_1} = \frac{\Delta H^\circ_{rxn}}{R}(\frac{1}{T_1} - \frac{1}{T_2})$$

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.97	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.95	43 **Tc** [97]	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
37 **Cs** 132.91	56 **Ba** 137.33		72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** [209]	85 **At** [210]	86 **Rn** [222]
87 **Fr** [223]	88 **Ra** [226]		104 **Rf** [267]	105 **Db** [268]	106 **Sg** [269]	107 **Bh** [270]	108 **Hs** [269]	109 **Mt** [277]	110 **Ds** [281]	111 **Rg** [282]	112 **Cn** [285]	113 **Nh** [286]	114 **Fl** [290]	115 **Mc** [290]	116 **Lv** [293]	117 **Ts** [294]	118 **Og** [294]
		57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97	
		89 **Ac** [227]	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** [237]	94 **Pu** [244]	95 **Am** [243]	96 **Cm** [247]	97 **Bk** [247]	98 **Cf** [251]	99 **Es** [252]	100 **Fm** [257]	101 **Md** [258]	102 **No** [259]	103 **Lr** [262]	