Practice exam for final exam, Chem 1210, Dr. Wu

Note:

- The exam time is 1hr48 minutes. Try to finish this practice exam in the same time.

[handwritten: Large size, strong intermolecular interaction.]

1. Which of the following gases will exhibit the least ideal behavior?

   (a) N_2 ✓ (b) N_2H_4 (c) CH_4 (d) Ne   (e) F_2

2. Which of the following effects will make PV/RT **less than 1** for a 1.0 mole sample of a real gas?

   (a) The gas molecules are large enough to occupy a substantial amount of space
   (b) A large number of molecules have speeds greater than the average speed.
   (c) The gas molecules have very low molecular weights.
   ✓ (d) The gas molecules attract one another   *[handwritten: ← reduce P]*
   (e) The gas molecules are placed in a larger container

3. Which of the following substances has the **lowest** normal boiling point?

   (a) H_2O ✓ (b) H_2S (c) H_2Se (d) H_2Te

   [handwritten graph labeled b.P. with axis points O, S, Se, T; "polar."]

4. For each of the following pairs determine the substance with the higher normal boiling point: (1) Cl_2 or Br_2, (2) acetic acid CH_3COOH or 1-propanol $CH_3CH_2CH_2OH$, (3) SO_2 or CO_2.   *[handwritten: 2 h-bonds]*

   (a) Higher normal boiling point = Cl_2, CH_3COOH and SO_2
   (b) Higher normal boiling point = Br_2, $CH_3CH_2CH_2OH$ and SO_2
   (c) Higher normal boiling point = Cl_2, CH_3COOH and SO_2
   ✓ (d) Higher normal boiling point = Br_2, CH_3COOH and SO_2
   (e) Higher normal boiling point = Br_2, CH_3COOH and CO_2
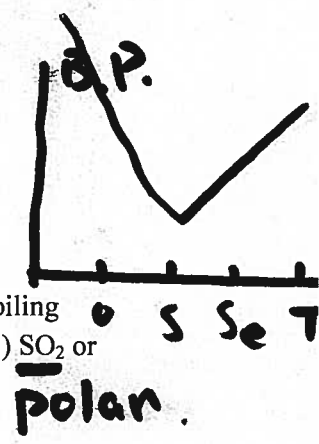
5. Which of the following phase transitions is exothermic?
   (a) Vaporization
   (b) Melting
   (c) Sublimation
   ✓ (d) Freezing
   (e) None of the above processes are exothermic

6. Which of the following statements regarding viscosity is **FALSE**?

(a) Viscosity increases as the strength of the intermolecular forces increases
(b) Viscosity increases as the temperature decreases
(c) Viscosity is generally higher for a liquid with large nonpolar molecules than it is for a liquid with small nonpolar molecules
✓(d) **All other things being equal viscosity is higher for a liquid with rigid molecules than it is for a liquid with flexible molecules**
(e) As the number of hydrogen bonds a molecule can form increases the viscosity increases

easy to entangle → higher viscosity

7. If 40.0 kJ is added to 36.0 g of solid H_2O (ice) initially at a temperature of −25.0 °C what is the final temperature of the H_2O? The specific heat of solid H_2O is 2.03 J/g·K, liquid H_2O is 4.18 J/g·K, and gaseous H_2O is 1.84 J/g·K. The heat of fusion is 6.01 kJ/mol and the heat of vaporization is 40.67 kJ mol. The melting and boiling points of water are 0 and 100 °C respectively.

(a) 273 K
(b) 312 K
(c) 405 K
✓(d) 373 K
(e) 380 K
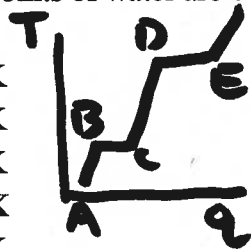
heating A−B of ice
$$q_{A-B} = 2.03 \times 36.0 \times (0-(-25))$$
$$= 1827 J = 1.83 kJ$$
melting B−C
$$q_{B-C} = 36.0 \times \frac{1 mol}{18.0 g} \times 6.01$$
$$= 12.0 kJ$$

8. Which of the following descriptions best describes the characteristics of molecules that are prone to form liquid crystalline phases?

(a) Nonpolar, rigid molecules with a rodlike shape
✓(b) **Polar, rigid molecules with a rodlike shape**
(c) Nonpolar, flexible molecules with a spherical shape
(d) Polar, rigid molecules with a spherical shape
(e) Polar, flexible molecules with a rodlike shape

polar ⟹ favors directional alignment.

heating of water
$$q_{C-D} = 36.0 \times 4.18 \times \frac{100}{}$$
$$= 15048 J$$
$$= 15.0 kJ$$

vaporization
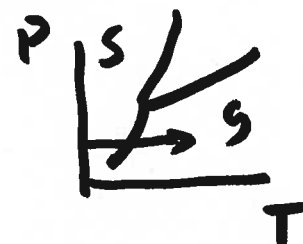$$q_{DE} = 36.0 \times \frac{1 mol}{18.0 g} \times 40.67$$
$$= 81.34 kJ$$

40 kJ can only reach D → E

9. The table below gives the temperature and pressure of the triple point for five different substances.

Substance	Temperature (K)	Pressure (atm)
Xe	161	0.80
UF_6	337	1.50
I_2	387	0.12
CO	68	0.15
Zn	693	6.4×10^{-4}

On heating from low temperature at 1 atm of pressure which substance is most likely to sublime rather than melt?

(a) Xe ✔ **(b) UF₆** (c) I_2 (d) CO (e) Zn *at T- Point >1 atm*

Pressure

10. Consider the properties of ruthenium (IV) oxide and ruthenium (VIII) oxide given in the table below

| Compound	Appearance	Melting point	Electrical Properties	Solubility in H_2O
RuO_2	Black crystalline solid	1300 °C	Conducting	Insoluble
RuO_4	Yellow crystalline solid	25 °C	Insulating	Slightly soluble

How would you classify these two solids?
a. Both RuO_2 and RuO_4 are ionic solids
b. Both RuO_2 and RuO_4 are metallic solids
c. Both RuO_2 and RuO_4 are molecular solids
✔ **d. RuO₂ is a covalent-network solid and RuO₄ is a molecular solid**
e. RuO_2 is a ionic solid and $GeBr_4$ is an molecular solid

11. For the 2D crystal structure shown below what is the lattice type and how many atoms are there per unit cell?
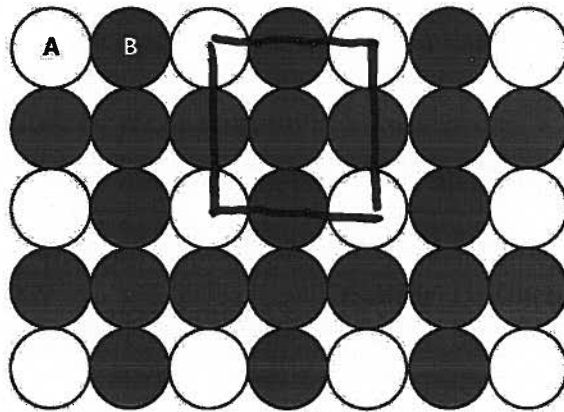

    (a) Lattice = rectangular, Atoms per unit cell = 1 A + 2 B
    (b) Lattice = rectangular, Atoms per unit cell = 1 A + 3 B
    ✓(c) **Lattice = square, Atoms per unit cell = 1 A + 3 B**
    (d) Lattice = square, Atoms per unit cell = 1 A + 1 B
    (e) Lattice = square, Atoms per unit cell = 1 A + 2 B

12. For the 2D crystal structure shown below what is the lattice type and how many atoms are there per unit cell?
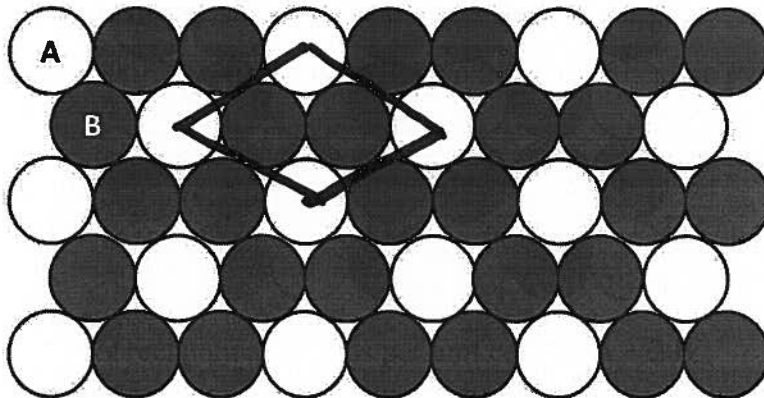
    (a) Lattice = hexagonal, Atoms per unit cell = 1 A + 1 B
    (b) Lattice = oblique, Atoms per unit cell = 1 A + 2 B
    (c) Lattice = centered rectangular, Atoms per unit cell = 2 A + 4 B
    (d) Lattice = rectangular, Atoms per unit cell = 1 A + 1 B
    ✓(e) **Lattice = hexagonal, Atoms per unit cell = 1 A + 2 B**

13. Which of the following properties of metals cannot be adequately explained by the electron sea model?
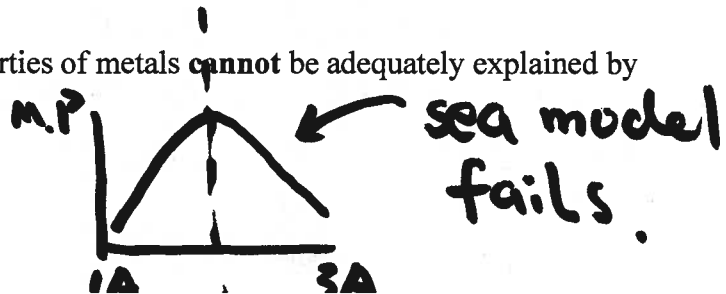
(a) The high electrical conductivity of metals

(b) The high thermal conductivity of metals

(c) The close packed structures of most metals

(d) The high melting points of metals in the middle of the transition series, like rhenium (Re) and tungsten (W)

✓ **(e) The low melting points of metals at the very end of the transition series, like cadmium (Cd) and mercury (Hg)**

→ 2 atoms per unit cell.

14. Tantalum crystallizes with a body centered cubic structure. Given the molar mass (180.95 g/mol) and the density of tantalum, $\rho = 16.69$ g/cm³ at 20 °C, what value would you calculate for the radius of a tantalum atom?

① calculate edge length

(a) 1.16 Å (0.116 nm)
(b) 1.25 Å (0.125 nm)
(c) 1.35 Å (0.135 nm)
✓(d) **1.42 Å (0.142 nm)**
(e) 1.54 Å (0.154 nm)

$$a = \sqrt[3]{V} = \sqrt[3]{\frac{m}{\rho}}$$

$$= \sqrt[3]{\frac{2 \times 180.95 \times \frac{1}{6.02 \times 10^{23}}}{16.69}} = 3.3 \times 10^{-8} \text{cm}$$

15. Which of the following metals will have the highest melting point: Rb, Re, Sr, Cd or Au?

middle of transition series = 3.3 Å

a. Rb   ✓ b. Re   c. Sr   d. Cd   e. Au

② for bCC

16. One unit cell of the crystal structure of a cubic compound that forms between copper and oxygen is shown below (the black spheres are copper and the gray spheres are oxygen). If the density of this compound is 4.95 g/cm³, and the ionic radius of the oxide ion is 1.26 Å, what is the radius of the copper ion? Assume the atoms touch along the bonds shown in the figure.

$4r = \sqrt{3}a$

$r = \frac{\sqrt{3}}{4} \times 3.3$

$= 1.42 \text{Å}$

a. 0.46 Å
b. 0.60 Å
✓ c. **0.74 Å**
d. 0.96 Å
e. 1.28 Å

in a unit cell

$4Cu + 2O$

① calculate the edge length.

Cu
O
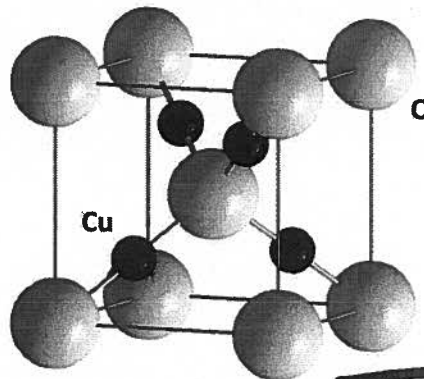
17. If you were to take the zinc blende crystal structure and make all of the atoms the same, what structure type

$a = \sqrt[3]{V} = \sqrt[3]{\frac{4m_{Cu} + 2m_O}{\rho}}$

body

② bond diagonal

would result?

    (a)   Hexagonal close packed metal (e.g. Zn)
    (b)   Face centered cubic metal (e.g. Al)
    (c)   Body centered cubic metal (e.g. Na)
    (d)   Primitive cubic metal (e.g. Po)
✓ (e)   **Diamond structure (e.g. Si)**

18. How many electrons, protons and neutrons does $^{87}Sr^{2+}$ have?

38

- (a) 38 protons, 49 neutrons and 38 electrons
- (b) 40 protons, 47 neutrons and 38 electrons
- ✓(c) 38 protons, 49 neutrons and 36 electrons
- (d) 38 protons, 38 neutrons and 49 electrons
- (e) none of the above are correct

19. What is the empirical formula of the ionic compound that forms between calcium and fluorine?

2^+

1^-

- (a) CaF
- (b) Ca_2F
- (c) Ca_2F_3
- (d) CaF_3
- ✓(e) CaF_2

20. The mineral corundum (which is the host structure for sapphires and rubies) has the formula Al_2O_3. If the density of corundum is 3.97 g/cm³ how many aluminum atoms are contained in a corundum crystal with a volume of 0.250 cm³?

- (a) 5.86 x 10²¹
- (b) 4.69 x 10²²
- ✓(c) 1.17 x 10²²
- (d) 7.12 x 10²²
- (e) none of the above

$$2 \times \frac{0.250}{V} \times \frac{3.97}{g} \times \frac{1\ mol}{2\times27.0+3\times16.0}$$

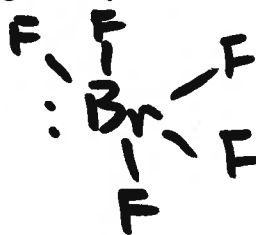$$= 0.0194\ mol \times \frac{6.02\times10^{23}}{1\ mol}$$

$$= 1.17\times10^{23}$$

21. Which of the following would you expect to have the shortest oxygen-oxygen bond distance?

- (a) O_2^-
- (b) O_2
- (c) O_2^+
- (d) O_2^{2-}
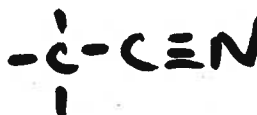- ✓(e) O_2^{2+} bond order = 3

22. Using VSEPR theory, predict the molecular geometry of BrF_5.

- (a) octahedral
- (b) square pyramidal ✓
- (c) T-shaped
- (d) trigonal bipyramidal
- (e) none of the above

23. How many sigma (s) and pi (p) bonds are there in H_3CCN?

- (a) 5 s and 2 p bonds ✓
- (b) 4 s and 3 p bonds
- (c) 6 s and 1 p bonds
- (d) 4 s and 2 p bonds
- (e) 7 s and 0 p bonds

24. Identify the atom(s) whose oxidation number changes, during the course of the following oxidation-reduction reaction:

$$\overset{+4}{Mn}O_2(s) + 4H\overset{-1}{Cl}(aq) \rightarrow \overset{+2}{Mn}Cl_2(aq) + \overset{0}{Cl_2}(g) + 2H_2O(l)$$

- (a) Mn
- (b) O
- (c) Cl
- (d) H
- (e) both Mn & Cl ✓

25. Arrange the following bonds in order of increasing polarity: C–N, B–F, C–F, and C–O.

- (a) Least Polar C–N < C–O < C–F < B–F Most Polar
- (b) Least Polar B–F < C–F < C–O < C–N Most Polar
- (c) Least Polar C–N < C–F < C–O < B–F Most Polar ✓
- (d) Least Polar C–N < B–F < C–F < C–O Most Polar
- (e) Least Polar C–N < B–F < C–O < C–F Most Polar

26. If you balance the following equation and sum the coefficients what number do you obtain?

$\underline{a}\ PCl_5(l) + \underline{b}\ H_2O(l) \rightarrow \underline{c}\ H_3PO_4(aq) + \underline{d}\ HCl(aq)$
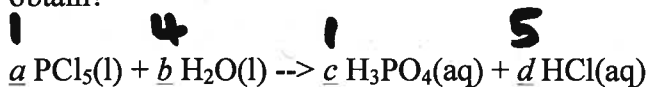
- (a) $a + b + c + d = 10$
- (b) $a + b + c + d = 4$
- (c) $a + b + c + d = 19$
- (d) $a + b + c + d = 11$ ✓
- (e) none of the above

27. Which of the following atoms/ions will have the **largest** radius?

- ✓ (a) Se^{2-}
- (b) Kr
- (c) Br^-
- (d) Y^{3+}
- (e) Rb^+

28. Arrange the following atoms in order of increasing first ionization energy: Cl, Rb, F, P, Ca, Cl.

~~Al~~ ~~Mg~~

- (a) Lowest IE F < Cl < P < ~~Al~~ < ~~Mg~~ < Rb Highest IE
- (b) Lowest IE Rb < ~~Mg~~ < ~~Al~~ < P < F < Cl Highest IE
- (c) Lowest IE Rb < ~~Al~~ < ~~Mg~~ < P < ~~Cl~~ < F Highest IE
- (d) Lowest IE Rb < ~~Mg~~ < ~~Al~~ < P < Cl < F Highest IE
- (e) Lowest IE Rb < F < ~~Mg~~ < ~~Al~~ < P < Cl Highest IE

29. What is the proper electron configuration for Ag^+?

- (a) $[Kr]\ 5s^2 4d^9$
- (b) $[Kr]\ 5s^2 4d^8$
- (c) $[Kr]\ 5s^1 4d^{10}$
- ✓ (d) $[Kr]\ 4d^{10}$
- (e) none of the above

30. The m_l (magnetic) quantum number for an electron in a 3p orbital

- (a) can have any integer value from 0 to 3
- ✓ (b) may be -1
- (c) may be +1/2 or −1/2
- (d) is three
- (e) both (a) and (b) are correct

$l = 1$

$m_l = -1, 0, +1$

31. What of the following photons falls into the visible region (wavelength between 400 - 700 nm) of the electromagnetic spectrum.

- (a) A photon with an energy of 1.2×10^{-18} J
- (b) A photon with a wavelength of 3.15×10^2 m
- ✓ (c) A photon with a frequency of 6.0×10^{14} s^{-1}
- (d) A photon with a wavelength of 50 nm
- (e) None of the above photons is in the visible.

$E = h\nu = h\dfrac{c}{\lambda}$

(a) $\lambda = \dfrac{6.626\times10^{-34} \times 3\times10^{8}}{1.2\times10^{-18}}$ ✗

$= 1.66\times10^{-7}$ m

$= 166$ nm

32. Given the following standard enthalpies of formation:

(c) $\lambda = \dfrac{c}{\nu} = \dfrac{3\times10^{8}}{6.0\times10^{14}}$

$= 0.5\times10^{-6}$ m $= 500$ nm ✓

- ΔH_f° (Fe$_2$O$_3$) = -822 kJ/mol
- ΔH_f° (FeCl$_3$) = -400 kJ/mol
- ΔH_f° (HCl) = -92 kJ/mol
- ΔH_f° (H$_2$O) = -242 kJ/mol

What is the enthalpy change, ΔH, for the reaction:

$Fe_2O_3(s) + 6HCl(g) \rightarrow 2FeCl_3(s) + 3H_2O(g)$

- (a) 152 kJ
- ✓(b) −152 kJ
- (c) 272 kJ
- (d) −272 kJ
- (e) None of the above

$\Delta H = 2 \times (-400) + 3(-242)$
$- (-822) - 6(-92)$
$= -152$

33. What is the standard enthalpy of formation of Mg(OH)$_2$, given the following data:

$2Mg(s) + O_2(g) \rightarrow 2MgO(s) \quad \Delta H^\circ = -1204 \text{ kJ} \quad \textcircled{1}$

$Mg(OH)_2(s) \rightarrow MgO(s) + H_2O(l) \quad \Delta H^\circ = +37 \text{ kJ} \quad \textcircled{2}$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \quad \Delta H^\circ = -572 \text{ kJ} \quad \textcircled{3}$
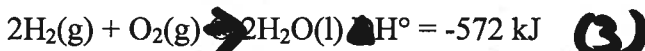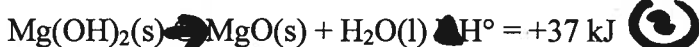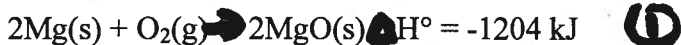
- (a) DH$_f^\circ$ [Mg(OH)$_2$] = -1739 kJ/mol
- (b) DH$_f^\circ$ [Mg(OH)$_2$] = +925 kJ/mol
- ✓(c) DH$_f^\circ$ [Mg(OH)$_2$] = -925 kJ/mol
- (d) DH$_f^\circ$ [Mg(OH)$_2$] = -1850 kJ/mol
- (e) None of the above

$Mg(s) + O_2(s) + H_2(s)$
$\rightarrow Mg(OH)_2(s)$

$\Delta H_f = -\Delta H^\circ(2)$
$+ \frac{1}{2} \Delta H^\circ(3) + \frac{1}{2} \Delta H^\circ(1)$
$= -925$

34. If 270 J of heat is required to raise the temperature of a 15.0 g sample of an unknown metal from 23° C to 43° C. Given the following specific heat values, determine the identity of the metal.

$S = \dfrac{270}{15.0 \times 20} = 0.9$

- (a) Iron (C$_s$ = 0.45 J/g-K)
- ✓(b) Aluminum (C$_s$ = 0.90 J/g-K)
- (c) Silicon (C$_s$ = 0.70 J/g-K)
- (d) Nickel (C$_s$ = 0.11 J/g-K)
- (e) Magnesium (C$_s$ = 0.24 J/g-K)

35. What is the molarity of a solution produced by mixing 50.0 mL of 0.200 M NaCl solution with 100.0 mL of 0.100 M NaCl solution?
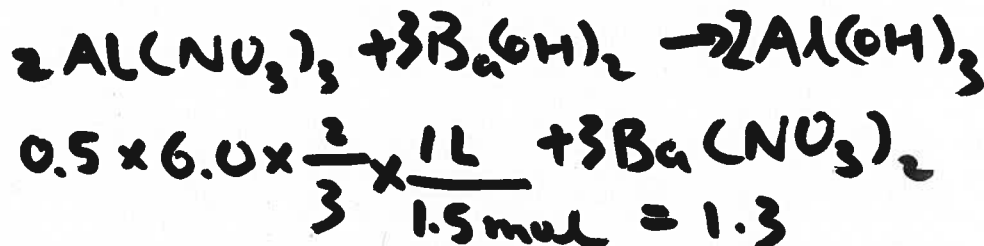
- (a) 0.300 M
- (b) 2.00 M
- ✓(c) 0.133 M
- (d) 0.15 M

$\dfrac{50 \times 0.2 + 100 \times 0.1}{50 + 100} = 0.133$

- (e) None of the above

36. What quantity of 1.5 M $Al(NO_3)_3$ solution must be added to 0.500 L of 6.0 M $Ba(OH)_2$ solution to completely precipitate out all of the hydroxide ions?

- ✓(a) 1.3 L
- (b) 2.0 L
- (c) 3.0 L
- (d) 0.50 L
- (e) 0.22 L

$$2 AL(NO_3)_3 + 3Ba(OH)_2 \rightarrow 2Al(OH)_3$$

$$0.5 \times 6.0 \times \frac{2}{3} \times \frac{1L}{1.5\,mol} + 3Ba(NO_3)_2 = 1.3$$

37. Use the activity series to determine which of the following ions is capable of oxidizing copper metal to form Cu^{2+} cations?

- (a) Na^+
- (b) Sn^{2+}
- ✓(c) Pt^{2+}
- (d) Zn^{2+}
- (e) Both (a) and (b)

38. [7.5 Points] Which of the following has the largest number of <u>chlorine atoms</u>?

- (a) 100 mL of a 1.0 M $SrCl_2$ solution **0.2 mol.**
- (b) 6.02×10^{22} Cl_2 molecules **0.2 mol**
- (c) 10.0 g of NaCl
- (d) 100 mL of a 2.0 M $HClO_3$ solution **0.2 mol.**
- ✓(e) 10.0 g of LiCl

$$10.0 \times \frac{1}{6.9 + 35.5} = 0.24$$

39. If 3.00 g of silicon dioxide (MW = 60.09 g/mol) is reacted with 4.50 g of carbon (AW = 12.01 g/mol) according to the following reaction:

$$SiO_2(s) + 3C(s) \rightarrow SiC(s) + 2CO(g)$$

What is the theoretical yield of SiC (MW = 40.10 g/mol)?

- (a) 5.01 g
- ✓(b) 2.00 g
- (c) 15.0 g
- (d) 1.54 g
- (e) None of the above

$$3.00 \times \frac{1}{60.09} \times \frac{1}{1} \times 40.10$$

$$= 2.00$$

40. What is the formula of magnesium perchlorate?

- (a) $MgCl_2$
- (b) $MgClO_4$
- (c) $Mg(ClO_3)_2$
- ✓ (d) $Mg(ClO_4)_2$
- (e) $MgClO_2$

$2+$ ClO_4^-