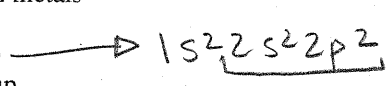


### Ionization Energies for Element X

	1st	2nd	3rd	4th	5th	6th	7th
Ionization Energy (kJ mol <sup>-1</sup> )	787	1,580	3,200	4,400	16,000	20,000	24,000

39. The first seven ionization energies of element X are shown in the table above. On the basis of these data, element X is most likely a member of which of the following groups (families) of elements?

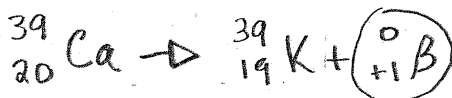
- (A) Alkaline earth metals
- (B) Boron group
- (C) Carbon group
- (D) Nitrogen group
- (E) Halogen group



Big jump between 4<sup>th</sup> & 5<sup>th</sup>!  
First 4 e<sup>-</sup> relatively easy to remove.

40. Which of the following particles is emitted by an atom of <sup>39</sup>Ca when it decays to produce an atom of <sup>39</sup>K?

- alpha* (A) <sup>4</sup>He
- neutron* (B) <sup>1</sup>n
- hydrogen-1* (C) <sup>1</sup>H
- (D) β<sup>-</sup>
- (E) β<sup>+</sup>



called a positron!

41. At approximately what temperature will 40. g of argon gas at 2.0 atm occupy a volume of 22.4 L?

- (A) 1,200 K
- (B) 600 K
- (C) 550 K
- (D) 270 K
- (E) 140 K

40g = 1 mole  
PV = nRT  
 $T = \frac{PV}{nR} = \frac{(2)(22.4)}{(1)(.08)} \approx \frac{44}{0.1}$

42. Which of the following aqueous solutions has the highest boiling point at 1.0 atm?

- (A) 0.20 M CaCl<sub>2</sub> → 0.6 M ions
- (B) 0.25 M Na<sub>2</sub>SO<sub>4</sub> → 0.75 M ions
- (C) 0.30 M NaCl → 0.6 M ions
- (D) 0.30 M KBr → 0.6 M ions
- (E) 0.40 M C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> → 0.4 M solute

→ ΔT<sub>b</sub> = (i)(K<sub>b</sub>)(m)

43. A certain reaction is spontaneous at temperatures below 400. K but is not spontaneous at temperatures above 400. K. If ΔH° for the reaction is -20. kJ mol<sup>-1</sup> and it is assumed that ΔH° and ΔS° do not change appreciably with temperature, then the value of ΔS° for the reaction is

- (A) -50. J mol<sup>-1</sup> K<sup>-1</sup>
- (B) -20. J mol<sup>-1</sup> K<sup>-1</sup>
- (C) -0.050 J mol<sup>-1</sup> K<sup>-1</sup>
- (D) 20. J mol<sup>-1</sup> K<sup>-1</sup>
- (E) 8,000 J mol<sup>-1</sup> K<sup>-1</sup>

ΔG = 0  
equilib.

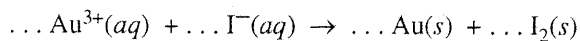
ΔG = ΔH - TΔS  
0 = -20 - (400)(ΔS)  
20 = -400(ΔS)  
                    
-400      -400

44. A sample of a solution of RbCl (molar mass 121 g mol<sup>-1</sup>) contains 11.0 percent RbCl by mass. From the following information, what is needed to determine the molarity of RbCl in the solution?

- I. Mass of the sample
  - II. Volume of the sample
  - III. Temperature of the sample
- (A) I only
  - (B) II only
  - (C) I and II only
  - (D) II and III only
  - (E) I, II, and III

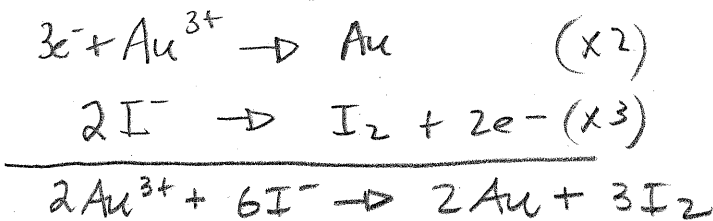
11.0% =  $\frac{11 \text{ g RbCl}}{100 \text{ g sol'n}}$

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45. When the equation above is balanced using the lowest whole-number coefficients, the coefficient for  $\text{I}_2(\text{s})$  is

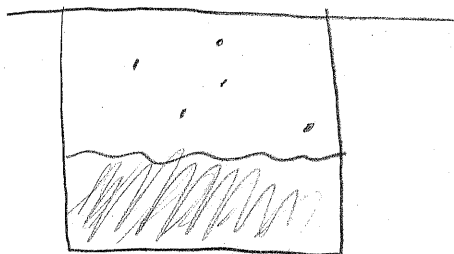
- (A) 8
- (B) 6
- (C) 4
- (D) 3
- (E) 2



46. A closed rigid container contains distilled water and  $\text{N}_2(\text{g})$  at equilibrium. Actions that would increase the concentration of  $\text{N}_2(\text{g})$  in the water include which of the following?

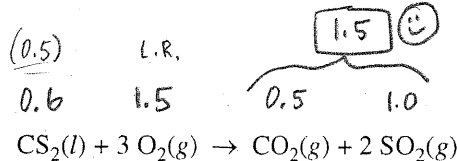
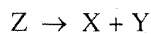
- I. Shaking the container vigorously
- II. Raising the temperature of the water
- III. Injecting more  $\text{N}_2(\text{g})$  into the container

- (A) I only
- (B) II only
- (C) III only
- (D) I and II only
- (E) I, II, and III

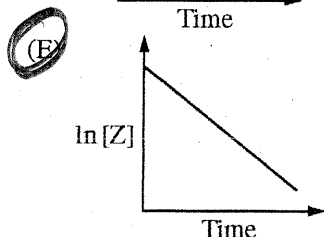
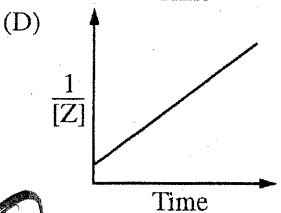
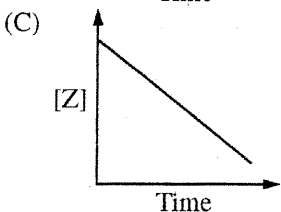
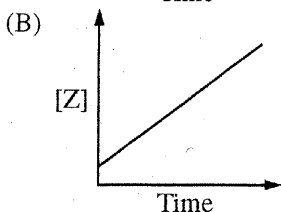
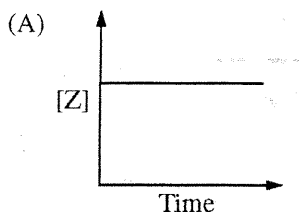


The higher the pressure, the more soluble the gas.  
(HENRY'S LAW)

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47. A pure substance Z decomposes into two products, X and Y, as shown by the equation above. Which of the following graphs of the concentration of Z versus time is consistent with the rate of the reaction being first order with respect to Z?



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

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

$$y = mx + b$$

48. When 0.60 mol of  $CS_2(l)$  reacts as completely as possible with 1.5 mol of  $O_2(g)$  according to the equation above, the total number of moles of reaction products is

- (A) 2.4 mol  
 (B) 2.1 mol  
 (C) 1.8 mol  
 (D) 1.5 mol  
 (E) 0.75 mol

Questions 49-50 refer to an experiment to determine the value of the heat of fusion of ice. A student used a calorimeter consisting of a polystyrene cup and a thermometer. The cup was weighed, then filled halfway with warm water, then weighed again. The temperature of the water was measured, and some ice cubes from a  $0^\circ C$  ice bath were added to the cup. The mixture was gently stirred as the ice melted, and the lowest temperature reached by the water in the cup was recorded. The cup and its contents were weighed again.

49. The purpose of weighing the cup and its contents again at the end of the experiment was to

- (A) determine the mass of ice that was added  
 (B) determine the mass of the thermometer  
 (C) determine the mass of water that evaporated  
 (D) verify the mass of water that was cooled  
 (E) verify the mass of the calorimeter cup

50. Suppose that during the experiment, a significant amount of water from the ice bath adhered to the ice cubes. How does this affect the calculated value for the heat of fusion of ice?

- (A) The calculated value is too large because less warm water had to be cooled.  
 (B) The calculated value is too large because more cold water had to be heated.  
 (C) The calculated value is too small because less ice was added than the student assumed.  
 (D) The calculated value is too small because the total mass of the calorimeter contents was too large.  
 (E) There is no effect on the calculated value because the water adhered to the ice cubes was at  $0^\circ C$ .

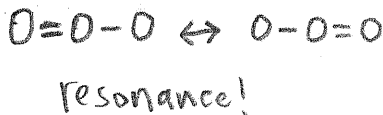
$$\Delta H = \frac{KJ}{mole}$$

← mol too high...  
 $\Delta H$  too low =

GO ON TO THE NEXT PAGE.

51. Which of the following molecules contains bonds that have a bond order of 1.5 ?

- (A) N<sub>2</sub>
- (B) O<sub>3</sub>
- (C) NH<sub>3</sub>
- (D) CO<sub>2</sub>
- (E) CH<sub>2</sub>CH<sub>2</sub>



52. Of the following metals, which reacts violently with water at 298 K?

- (A) Au
- (B) Ag
- (C) Cu
- (D) Mg
- (E) Rb

1A metal

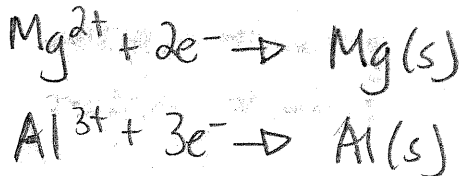
Temp. does not change during phase changes!

53. Heat energy is added slowly to a pure solid covalent compound at its melting point. About half of the solid melts to become a liquid. Which of the following must be true about this process?

- (A) Covalent bonds are broken as the solid melts.
- (B) The temperature of the solid/liquid mixture remains the same while heat is being added.
- (C) The intermolecular forces present among molecules become zero as the solid melts.
- (D) The volume of the compound increases as the solid melts to become a liquid.
- (E) The average kinetic energy of the molecules becomes greater as the molecules leave the solid state and enter the liquid state.

54. A steady electric current is passed through molten MgCl<sub>2</sub> for exactly 1.00 hour, producing 243 g of Mg metal. If the same current is passed through molten AlCl<sub>3</sub> for 1.00 hour, the mass of Al metal produced is closest to

- (A) 27.0 g
- (B) 54.0 g
- (C) 120. g
- (D) 180. g
- (E) 270. g



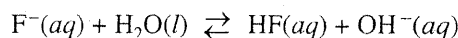
Calculate current by using Mg:

$$x \frac{\text{mol } e^-}{\text{hour}} = \left| \frac{243 \text{ g Mg}}{1 \text{ hour}} \cdot \frac{1 \text{ mol Mg}}{24.3 \text{ g Mg}} \cdot \frac{2 \text{ mol } e^-}{1 \text{ mol Mg}} \right| = 20 \frac{\text{mol } e^-}{\text{hour}}$$

} same current for aluminum!

$$x \text{ g Al} = \left| \frac{1 \text{ hour}}{1 \text{ hr}} \cdot \frac{20 \text{ mol } e^-}{3 \text{ mol } e^-} \cdot \frac{1 \text{ mol Al}}{1 \text{ mol Al}} \cdot \frac{27 \text{ g Al}}{1 \text{ mol Al}} \right| = \frac{20 \cdot 27}{3} = 20 \cdot 9 = 180 \text{ grams}$$

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B            A            CA            CB

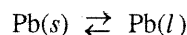
55. Which of the following species, if any, acts as a Brønsted-Lowry base in the reversible reaction represented above?

- (A) HF(aq)
- (B) H<sub>2</sub>O(l)
- (C) F<sup>-</sup>(aq) only
- (D) Both F<sup>-</sup>(aq) and OH<sup>-</sup>(aq) act as Brønsted-Lowry bases.
- (E) No species acts as a Brønsted-Lowry base.

56. What is the empirical formula of a hydrocarbon that is 10.0 percent hydrogen by mass?

- (A) CH<sub>3</sub>
- (B) C<sub>2</sub>H<sub>5</sub>
- (C) C<sub>3</sub>H<sub>4</sub>
- (D) C<sub>4</sub>H<sub>9</sub>
- (E) C<sub>9</sub>H<sub>10</sub>

$$\frac{4}{40} = 10\%$$



57. Which of the following is true for the process represented above at 327°C and 1 atm? (The normal melting point of Pb(s) is 327°C.)

- (A) ΔH = 0
- (B) TΔS = 0
- (C) ΔS < 0
- (D) ΔH = TΔG
- (E) ΔH = TΔS

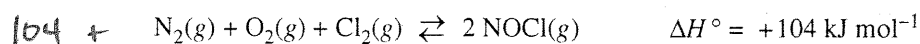
$$\Delta G = \Delta H - T\Delta S$$

$$0 = \Delta H - T\Delta S$$

$$\Delta H = T\Delta S$$

ΔG = 0 for equilibrium!  
like a phase change.

↑



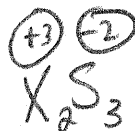
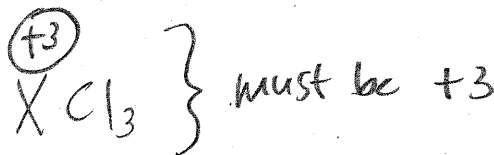
58. The equilibrium system represented above is contained in a sealed, rigid vessel. Which of the following will increase if the temperature of the mixture is raised?

- (A)  $[\text{N}_2(\text{g})]$
- (B) The rate of the forward reaction only
- (C) The rate of the reverse reaction only
- (D) The rates of both the forward and reverse reactions
- (E) The total number of moles of gas in the vessel

→ Both reactions speed up!  
(Equilibrium actually shifts right.)

59. If a metal X forms an ionic chloride with the formula  $\text{XCl}_3$ , then which of the following formulas is most likely to be that of a stable sulfide of X?

- (A)  $\text{XS}_2$
- (B)  $\text{X}_2\text{S}_3$
- (C)  $\text{XS}_6$
- (D)  $\text{X}(\text{SO}_3)_3$
- (E)  $\text{X}_2(\text{SO}_3)_3$



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Questions 60-61 refer to the figures below. The figures show portions of a buret used in a titration of an acid solution of known concentration with a saturated solution of  $\text{Ba}(\text{OH})_2$ . Figures 1 and 2 show the level of the  $\text{Ba}(\text{OH})_2$  solution at the start and at the endpoint of the titration, respectively. Phenolphthalein was used as the indicator for the titration.

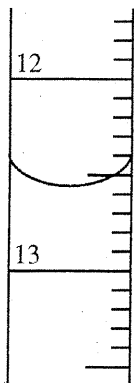


Figure 1

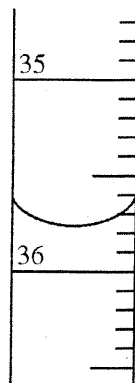


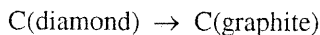
Figure 2

$$\begin{array}{r}
 \text{Ba}(\text{OH})_2 \\
 \hline
 35.8 \text{ mL} \\
 - 12.6 \text{ mL} \\
 \hline
 23.2 \text{ mL Ba}(\text{OH})_2
 \end{array}$$

answer to #61

60. What is the evidence that the endpoint of the titration has been reached?
- (A) The color of the solution in the buret changes from pink to colorless.
  - (B) The color of the solution in the buret changes from blue to red.
  - (C) The color of the contents of the flask below the buret changes from colorless to pink.
  - (D) The color of the contents of the flask below the buret changes from blue to red.
  - (E) The contents of the flask below the buret change from clear to cloudy.
61. The volume of saturated  $\text{Ba}(\text{OH})_2$  used to neutralize the acid was closest to
- (A) 6.60 mL
  - (B) 22.80 mL
  - (C) 23.02 mL
  - (D) 23.20 mL
  - (E) 29.80 mL

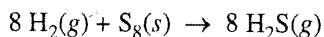
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62. For the reaction represented above, the standard Gibbs free energy change,  $\Delta G_{298}^\circ$ , has a value of  $-2.90 \text{ kJ mol}^{-1}$ . Which of the following best accounts for the observation that the reaction does NOT occur (i.e., diamond is stable) at 298 K and 1.00 atm?

- (A)  $\Delta S^\circ$  for the reaction is positive.  
 (B) The activation energy,  $E_a$ , for the reaction is very large.  $\Rightarrow$   
 (C) The reaction is slightly exothermic ( $\Delta H^\circ < 0$ ).  
 (D) Diamond has a density greater than that of graphite.  
 (E) Diamond has a heat capacity lower than that of graphite.

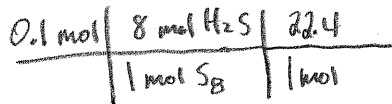
$\Rightarrow$  Eact must be REALLY high! That is why no observable reaction.



0.1 mol

63. When 25.6 g of  $\text{S}_8(\text{s})$  (molar mass  $256 \text{ g mol}^{-1}$ ) reacts completely with an excess of  $\text{H}_2(\text{g})$  according to the equation above, the volume of  $\text{H}_2\text{S}(\text{g})$ , measured at  $0^\circ\text{C}$  and  $1.00 \text{ atm}$ , produced is closest to

- (A) 30 L  
 (B) 20 L  
 (C) 10 L  
 (D) 5 L  
 (E) 2 L



STP

65. By mixing only 0.15 M HCl and 0.25 M HCl, it is possible to create all of the following solutions EXCEPT

- (A) 0.23 M HCl  
 (B) 0.21 M HCl  
 (C) 0.18 M HCl  
 (D) 0.16 M HCl

(E) 0.14 M HCl  $\Rightarrow$  cannot create a solution which is more dilute than either of

66. At  $25^\circ\text{C}$  a saturated solution of a metal hydroxide,  $\text{M}(\text{OH})_2$ , has a pH of 9.0. What is the value of the solubility-product constant,  $K_{sp}$ , of  $\text{M}(\text{OH})_2(\text{s})$  at  $25^\circ\text{C}$ ?

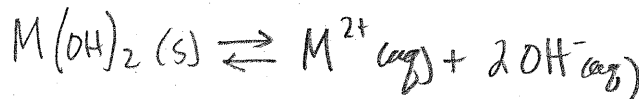
- (A)  $5.0 \times 10^{-28}$   
 (B)  $1.0 \times 10^{-27}$   
 (C)  $5.0 \times 10^{-19}$   
 (D)  $5.0 \times 10^{-16}$   
 (E)  $1.0 \times 10^{-15}$

pH = 9.0

pOH = 5.0

$[\text{OH}^-] = 1.0 \times 10^{-5}$

the original solutions. 😊



$[\text{M}^{2+}]$  is  $\frac{1}{2}$  of  $[\text{OH}^-]$

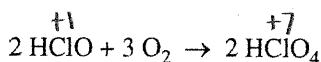
$0.5 \times 10^{-5} \text{ M}$  ( $1.0 \times 10^{-5} \text{ M}$ )  
 $\hookrightarrow 5.0 \times 10^{-6} \text{ M}$

$$K_{sp} = [\text{M}^{2+}][\text{OH}^-]^2$$

$$= (5.0 \times 10^{-6})(1.0 \times 10^{-5})(1.0 \times 10^{-5})$$

$K_{sp} = 5.0 \times 10^{-16}$

GO ON TO THE NEXT PAGE.



64. As the reaction represented above proceeds to the right, the oxidation number of chlorine changes from

- (A) -1 to +3  
 (B) -1 to +5  
 (C) +1 to +5  
 (D) +1 to +7  
 (E) +3 to +7

$$M = \frac{\text{mol}}{L} \quad L = \frac{\text{mol}}{M} = \frac{0.0154 \text{ mol}}{0.154 \text{ M}} = 0.100 \text{ L} = 100 \text{ mL}$$

67. A student weighs out 0.0154 mol of pure, dry NaCl in order to prepare a 0.154 M NaCl solution. Of the following pieces of laboratory equipment, which would be most essential for preparing the solution?

- (A) Large crucible with lid
- (B) 50 mL volumetric pipet
- (C) 100 mL Erlenmeyer flask
- (D) 100 mL graduated beaker
- (E) 100 mL volumetric flask

⇒ Measures exactly 100 mL ☺

68. In which of the following are the chemical species correctly ordered from smallest radius to largest radius?

- (A) B < C < N
- (B) Ar < Xe < Kr
- (C) Cl < S < S<sup>2-</sup>
- (D) Na < Na<sup>+</sup> < K
- (E) K<sup>+</sup> < Ca<sup>2+</sup> < K

most protons... smallest  
Cl 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>5</sup> (17pt)

S 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>4</sup> (16pt)

S<sup>2-</sup> 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup> (16pt)

e<sup>-</sup>: e<sup>-</sup> repulsion

69. A large piece of wood can burn slowly, but wood in the form of sawdust can combust explosively. The primary reason for the difference is that compared with a large piece of wood, sawdust

- (A) has a greater surface area per kilogram
- (B) has a greater carbon content per kilogram
- (C) absorbs more atmospheric moisture per kilogram
- (D) contains more compounds that act as catalysts for combustion
- (E) contains more compounds that have higher heats of combustion

70. Of the following elements, which would be expected to have chemical properties most similar to those of sulfur, S?

- (A) Br
- (B) Cl
- (C) N
- (D) P
- (E) Se

S & Se both from the same family

71. When a solution is formed by adding some methanol, CH<sub>3</sub>OH, to water, processes that are endothermic include which of the following?

- I. Methanol molecules move water molecules apart as the methanol goes into solution.
- II. Water molecules move methanol molecules apart as the methanol goes into solution.
- III. Intermolecular attractions form between molecules of water and methanol as the methanol goes into solution.

- (A) I only
- (B) III only
- (C) I and II only
- (D) II and III only
- (E) I, II, and III

ENDO: energy is needed to separate solute particles from one another... and solvent particles from one another.

72. Of the following gases, which has the greatest average molecular speed at 298 K?

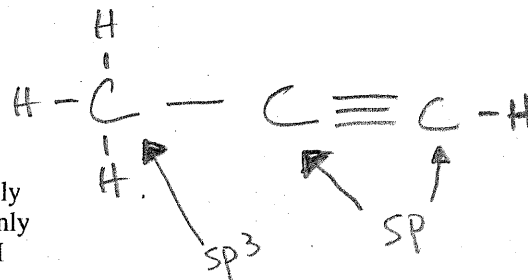
- (A) Cl<sub>2</sub>(g) — 71
- (B) NO(g) — 30
- (C) H<sub>2</sub>S(g) — 34
- (D) HCN(g) — 27
- (E) PH<sub>3</sub>(g) — 34

Gas w/ smallest MM is fastest!!

73. Types of hybridization exhibited by carbon atoms in a molecule of propyne, CH<sub>3</sub>CCH, include which of the following?

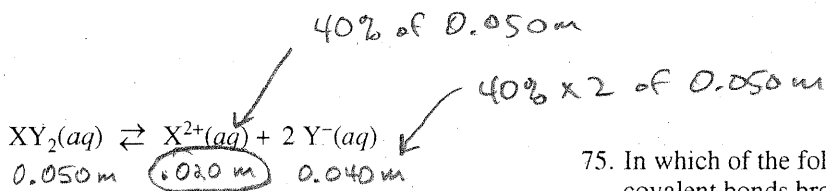
- I. sp
- II. sp<sup>2</sup>
- III. sp<sup>3</sup>

- (A) I only
- (B) III only
- (C) I and III only
- (D) II and III only
- (E) I, II, and III



GO ON TO THE NEXT PAGE.





74. A soluble compound  $XY_2$  dissociates in water according to the equation above. In a  $0.050\text{ m}$  solution of the compound, the  $XY_2(aq)$  species is 40.0 percent dissociated. In the solution, the number of moles of particles of solute per 1.0 kg of water is closest to ---

- (A) 0.15
- (B) 0.090**
- (C) 0.070
- (D) 0.040
- (E) 0.020

	mol after diss.
$XY_2$	0.030 m
$X^{2+}$	0.020 m
$2Y^{-}$	0.040 m
	0.090 m

75. In which of the following processes are covalent bonds broken?

- (A) Solid silver melts. → metallic bonds
- (B) Solid potassium chloride melts. → ionic bonds
- (C) Solid carbon (graphite) sublimes.** → cov. net. solid
- (D) Solid iodine sublimes. → IM forces
- (E) Glucose dissolves in water. → IM forces

THANKS FOR  
 DOING  
 PRACTICE  
 TEST  
 #2

**END OF SECTION I**

**IF YOU FINISH BEFORE TIME IS CALLED,  
YOU MAY CHECK YOUR WORK ON THIS SECTION.**

**DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.**

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