

## Multiple Choice

1. The mass of  $1.63 \times 10^{21}$  silicon atoms (in gram) is:
- A)  $2.71 \times 10^{-3}$     B)  $4.58 \times 10^{-3}$     C)  $1.04 \times 10^{-4}$     D)  $7.60 \times 10^{-2}$
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2. A student heated a piece of titanium metal in the presence of sulfur, and found that 3.70 g of the metal combined with enough sulfur to make 8.65 g of a "titanium sulfide compound". What is the empirical formula of the compound?
- A)  $\text{TiS}_3$     B)  $\text{TiS}_2$     C)  $\text{Ti}_2\text{S}$     D)  $\text{TiS}$
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3. Synthetic natural gas ( $\text{CH}_4$ ) can be made by the reaction of hydrogen with carbon monoxide.
- $$\text{H}_2 + \text{CO} \rightarrow \text{CH}_4 + \text{H}_2\text{O}$$
- Balance this equation and determine how many grams of  $\text{H}_2$  are required to react with 607 g of  $\text{CO}$ ?
- A) 130.0    B) 165.0    C) 143.0    D) 121.0
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4. What is the molarity of a solution that is 26.0% by mass phosphoric acid ( $\text{H}_3\text{PO}_4$ ) and that has a density of 1.155 g/mL?
- A) 2.58 M    B) 2.75 M    C) 2.22 M    D) 3.06 M
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5. How many liters of oxygen gas at  $153^\circ\text{C}$  and 0.820 atm can be produced by the reaction of 22.4 g of  $\text{KClO}_3$ ?
- $$2\text{KClO}_3(\text{s}) \rightarrow 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$$
- A) 3.00    B) 11.70    C) 14.20    D) 17.70
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6. At what temperature will a fixed mass of gas with a volume of 125 L at  $15^\circ\text{C}$  and 750 mmHg occupy a volume of 101 L at a pressure of 645 mmHg?
- A)  $-73^\circ\text{C}$     B)  $10^\circ\text{C}$     C)  $2^\circ\text{C}$     D)  $34^\circ\text{C}$
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7. Calculate the density in g/L of  $\text{SF}_6$  gas at  $27^\circ\text{C}$  and 0.50 atm pressure.
- A) 1.24    B) 2.96    C) 3.29    D) 3.83
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8. A sample of hydrogen was collected over water at  $21^\circ\text{C}$  and 685 mmHg. The volume of the container was 7.80 L. Calculate the mass of  $\text{H}_2(\text{g})$  collected. (Vapor pressure of water = 18.6 mmHg at  $21^\circ\text{C}$ ).
- A) 0.483 g    B) 0.522 g    C) 0.571 g    D) 0.587
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9. A glass containing 200 g of  $\text{H}_2\text{O}$  at  $20^\circ\text{C}$  was placed into a refrigerator. The water loses 11715 J as it cools to constant temperature. What is the new temperature? (The specific heat of water is  $4.184 \text{ J/g}\cdot^\circ\text{C}$ )
- A)  $0^\circ\text{C}$     B)  $2^\circ\text{C}$     C)  $4^\circ\text{C}$     D)  $6^\circ\text{C}$
-

10. Calculate the enthalpy change for the reaction:
- $$2\text{C}_8\text{H}_{18}(\text{l}) + 21\text{O}_2(\text{g}) \rightarrow 8\text{CO}(\text{g}) + 8\text{CO}_2(\text{g}) + 18\text{H}_2\text{O}(\text{l}) \quad \Delta\text{H}^\circ = ?$$
- Given:
- $$2\text{C}_8\text{H}_{18}(\text{l}) + 25\text{O}_2(\text{g}) \rightarrow 16\text{CO}_2(\text{g}) + 18\text{H}_2\text{O}(\text{l}) \quad \Delta\text{H}^\circ = -11020 \text{ kJ}$$
- $$2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) \quad \Delta\text{H}^\circ = -566.0 \text{ kJ}$$

- A) 13284 kJ                      B) -8756 kJ  
 C) -13284 kJ                      D) -6492 kJ
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11. The enthalpy of combustion of acetylene  $\text{C}_2\text{H}_2$  is:
- $$\text{C}_2\text{H}_2(\text{g}) + 5/2\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \quad \Delta\text{H}_{\text{rxn}}^\circ = -1299 \text{ kJ}$$
- Calculate the enthalpy of formation of acetylene (in kJ), given the following enthalpies of formation:  $\Delta\text{H}_f^\circ[\text{CO}_2(\text{g})] = -394 \text{ kJ/mol}$ ,  $\Delta\text{H}_f^\circ[\text{H}_2\text{O}(\text{l})] = -286 \text{ kJ/mol}$

- A) 225                      B) -149                      C) 149                      D) -225
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12. Calculate (in kJ) the change in internal energy,  $\Delta\text{E}^\circ$ , for the following reaction (at  $25^\circ\text{C}$ ):
- $$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$$

Knowing that:  $\Delta\text{H}_f^\circ \text{CH}_4(\text{g}) = -75 \text{ kJ}$ ,  $\Delta\text{H}_f^\circ \text{CO}_2(\text{g}) = -394 \text{ kJ}$  and  $\Delta\text{H}_f^\circ \text{H}_2\text{O}(\text{l}) = -286 \text{ kJ}$

- A) -891                      B) -886                      C) -896                      D) 891
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13. At  $10^\circ\text{C}$  one volume of water dissolves 3.10 volumes of chlorine gas,  $\text{Cl}_2$ , at 1 atm pressure. What is Henry's law constant in mol/L.atm (at  $10^\circ\text{C}$ )?

- A) 0.19                      B) 0.17                      C) 0.13                      D) 0.22
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14. What is the molar mass of toluene (in g/mol) if 0.85 g of toluene depresses the freezing point of 100 g of benzene by  $0.47^\circ\text{C}$ ?  $K_f = 5.12^\circ\text{C/m}$ .

- A) 92.6                      B) 78.0                      C) 70.7                      D) 81.8
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15. What is the osmotic pressure (in atm) of a solution that contains 13.7 g of urea,  $\text{CO}(\text{NH}_2)_2$ , dissolved in enough water to make 500 mL of solution at  $27^\circ\text{C}$ ?

- A) 7.75                      B) 9.15                      C) 10.65                      D) 11.25
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16. It takes 42 min for the concentration of a reactant in a first-order to drop from 0.45 M to 0.32 M at  $25^\circ\text{C}$ . How long will it take for the reaction to be 90% complete (in min).

- A) 284                      B) 212                      C) 198                      D) 175
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17. For the following reaction,  $\Delta\text{P}(\text{C}_6\text{H}_{14})/\Delta\text{t}$  was found to be  $-6.20 \times 10^{-3} \text{ atm/s}$ .



Determine the value of  $\Delta\text{P}(\text{H}_2)/\Delta\text{t}$  at the same time (in atm/s)

- A)  $1.55 \times 10^{-3}$                       B)  $-2.48 \times 10^{-2}$                       C)  $-1.55 \times 10^{-3}$                       D)  $2.48 \times 10^{-2}$
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18. The isomerization of methyl isocyanide ( $\text{CH}_3\text{NC}$ ).  

$$\text{CH}_3\text{NC} \rightarrow \text{CH}_3\text{NC}$$
 Follows first-order kinetics. The half-lives were found to be 161 min at  $199^\circ\text{C}$ , and 12.5 min at  $230^\circ\text{C}$ . Calculate the activation energy for this reaction (in kJ).
- A) 152                      B) 163                      C) 182                      D) 199
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19. For the following reaction system is at equilibrium:  

$$\text{CO}(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g})$$
 The result of removing some  $\text{CH}_4(\text{g})$  from the system is:
- A)  $\text{H}_2\text{O}$  is consumed.                      B) more  $\text{CH}_4$  &  $\text{H}_2\text{O}$  are produced.  
 C)  $K_p$  decreases.                              D) more  $\text{CO}$  is produced.
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20. 4.2 mol of oxygen and 4.0 mol of  $\text{NO}$  are introduced to an evacuated 0.50 L reaction vessel. At the temperature of the system, the equilibrium:  

$$2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$$
 Is reached when  $[\text{NO}] = 1.6 \text{ M}$ . Calculate  $K_c$  for the reaction.
- A) 16.8                      B) 14.6                      C) 8.2                      D) 3.1
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21. Phosgene,  $\text{COCl}_2$ , a poisonous gas decomposes according to the equation:  

$$\text{COCl}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$$
 If  $K_c = 0.083$  at  $900^\circ\text{C}$ , what is the value of  $K_p$ .
- A) 0.125                      B) 8.0                      C) 6.0                      D) 12.5
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22. The pH of 1.5 M methylamine,  $\text{CH}_3\text{NH}_2$ , solution is 12.41. What is the  $K_b$  value for methylamine?
- A)  $2.6 \times 10^{-2}$                       B)  $1.8 \times 10^{-5}$                       C)  $4.4 \times 10^{-4}$                       D)  $2.3 \times 10^{-11}$
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23. You are asked to go into the lab and prepare an acetic acid-sodium acetate buffer solution with a pH of 5.48. What molar ratio of  $\text{CH}_3\text{COONa}$  to  $\text{CH}_3\text{COOH}$  should be used?  

$$\frac{\text{CH}_3\text{COONa}}{\text{CH}_3\text{COOH}} = \quad (\text{K}_a \text{ CH}_3\text{COOH} = 1.8 \times 10^{-5})$$
- A) 1.82                      B) 0.84                      C) 1.19                      D) 5.44
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24. Calculate the pH of 80.0 ml of the 0.30 M  $\text{NH}_3$ /0.30 M  $\text{NH}_4\text{Cl}$  buffer solution when 20.0 mL of 0.050 M  $\text{NaOH}$  solution is added to it. ( $K_b \text{ NH}_3 = 1.8 \times 10^{-5}$ )
- A) 11.4                      B) 10.8                      C) 9.3                      D) 8.7
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25. In an electron microscope, electrons are accelerated to great velocities. Calculate the wavelength of an electron travelling with a velocity of  $7 \times 10^6$  meters/second. The mass of an electron is  $9.1 \times 10^{-28}$  g.
- A)  $1 \times 10^{-13}$  m                      B)  $1 \times 10^{-12}$  m                      C)  $1 \times 10^{-10}$  m                      D)  $1 \times 10^{-8}$  m
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26. Calculate the frequency of the light emitted by a hydrogen atom during a transition of its electron from the  $n = 4$  to the  $n = 1$  principle energy level. Recall

$$E_n = -21.8 \times 10^{-18} J \left( \frac{1}{n^2} \right)$$

- A)  $3.08 \times 10^{15} \text{ s}^{-1}$                       B)  $1.03 \times 10^8 \text{ s}^{-1}$   
C)  $2.06 \times 10^{14} \text{ s}^{-1}$                       D)  $8.22 \times 10^{14} \text{ s}^{-1}$
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27. Which one of the following elements should have the lowest ionization energy?

- A) Cl                      B) Na                      C) Be                      D) K
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28. A chromium atom has how many unpaired electrons?

- A) 2                      B) 4                      C) 5                      D) 6
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29. Which one of the following sets of quantum numbers is unacceptable?

- |                          | n | l | $m_l$ | $m_s$ |
|--------------------------|---|---|-------|-------|
| <input type="radio"/> A) | 4 | 3 | -2    | +1/2  |
| B)                       | 3 | 0 | 1     | -1/2  |
| C)                       | 3 | 0 | 0     | +1/2  |
| D)                       | 2 | 1 | 1     | -1/2  |
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30. The maximum number of electrons that can occupy an energy level described by the principal quantum number, n, is:

- A)  $n^2$                       B)  $2n$                       C)  $2n^2$                       D)  $2n+2$
-