

DO NOT OPEN THE EXAM UNTIL YOU ARE TOLD TO DO SO.

In the meantime, read this...

You will write all of your answers on the answer sheets, on the next two pages. At the end of the exam, turn in **your entire test booklet, with Answer Sheet, and your Scantron card.**

 Write your name:

-  on the front of the exam,
-  on the "Answer Sheet," and
-  on the Scantron card.

You may use your calculator and a pen or pencil. Please do not use green or red.

Problems marked \*\* come straight from the assigned homework or from worksheets in class.

Put all notes, books, etc away and out of sight. Turn off the ringers of electronic devices and put them away and out of sight. **Electronic devices (other than calculators) must be silenced and put away. Use of calculator functions on communication devices is not permitted. Sharing calculators is not permitted.** Points will be deducted for electronic devices in view or making noise, and devices will be confiscated.

No outside paper is allowed. If you need more scratch paper, ask one of the proctors.

Strategy hint: take a quick look over the whole exam before you start. If you see something that looks easy for you, go for it! It's good to get a few points in the bag right away.

Strategy hints for multiple choice:

- when you have determined that an option is not correct, mark it off so you don't have to check it again!
- even if you think you have found the right answer, look at the remaining answers to see if any of them are a better match.
- on calculation problems, show your work somewhere on the page. Even if you miss the problem, it certainly will be easier to see later where mistakes were made.

**Looking at another student's work, intentionally or accidentally, will not be tolerated. Students who seem to have trouble keeping their eyes on their own papers will be moved to the front of the room. Students who cheat earn a failing grade.**

DO NOT OPEN THE EXAM UNTIL YOU ARE TOLD TO DO SO.

**Check back over your exam and make sure you have completed all parts before turning in your paper!**

**Periodic Table of the Elements**

|                   |                   |                   |                    |                    |                    |                    |                    |                    |                    |                    |                   |                   |                   |                   |                   |                   |                   |                  |
|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|
| 1A                | 2A                |                   |                    |                    |                    |                    |                    |                    |                    |                    |                   | 3A                | 4A                | 5A                | 6A                | 7A                | 8A                |                  |
| 1<br>H<br>1.008   |                   |                   |                    |                    |                    |                    |                    |                    |                    |                    |                   |                   |                   |                   |                   |                   | 1<br>H<br>1.008   | 2<br>He<br>4.003 |
| 3<br>Li<br>6.941  | 4<br>Be<br>9.012  |                   |                    |                    |                    |                    |                    |                    |                    |                    |                   | 5<br>B<br>10.81   | 6<br>C<br>12.01   | 7<br>N<br>14.01   | 8<br>O<br>16.00   | 9<br>F<br>19.00   | 10<br>Ne<br>20.18 |                  |
| 11<br>Na<br>22.99 | 12<br>Mg<br>24.31 |                   |                    |                    |                    |                    |                    |                    |                    |                    |                   | 13<br>Al<br>26.98 | 14<br>Si<br>28.09 | 15<br>P<br>30.97  | 16<br>S<br>32.06  | 17<br>Cl<br>35.45 | 18<br>Ar<br>39.95 |                  |
| 19<br>K<br>39.10  | 20<br>Ca<br>40.08 | 21<br>Sc<br>44.96 | 22<br>Ti<br>47.87  | 23<br>V<br>50.94   | 24<br>Cr<br>52.00  | 25<br>Mn<br>54.94  | 26<br>Fe<br>55.85  | 27<br>Co<br>58.93  | 28<br>Ni<br>58.69  | 29<br>Cu<br>63.55  | 30<br>Zn<br>65.41 | 31<br>Ga<br>69.72 | 32<br>Ge<br>72.64 | 33<br>As<br>74.92 | 34<br>Se<br>78.96 | 35<br>Br<br>79.90 | 36<br>Kr<br>83.80 |                  |
| 37<br>Rb<br>85.47 | 38<br>Sr<br>87.62 | 39<br>Y<br>88.91  | 40<br>Zr<br>91.22  | 41<br>Nb<br>92.91  | 42<br>Mo<br>95.94  | 43<br>Tc<br>[98]   | 44<br>Ru<br>101.1  | 45<br>Rh<br>102.9  | 46<br>Pd<br>106.4  | 47<br>Ag<br>107.9  | 48<br>Cd<br>112.4 | 49<br>In<br>114.8 | 50<br>Sn<br>118.7 | 51<br>Sb<br>121.8 | 52<br>Te<br>127.6 | 53<br>I<br>126.9  | 54<br>Xe<br>131.3 |                  |
| 55<br>Cs<br>132.9 | 56<br>Ba<br>137.3 | 57<br>La<br>138.9 | 72<br>Hf<br>178.5  | 73<br>Ta<br>180.9  | 74<br>W<br>183.8   | 75<br>Re<br>186.2  | 76<br>Os<br>190.2  | 77<br>Ir<br>192.2  | 78<br>Pt<br>195.1  | 79<br>Au<br>197.0  | 80<br>Hg<br>200.6 | 81<br>Tl<br>204.4 | 82<br>Pb<br>207.2 | 83<br>Bi<br>209.0 | 84<br>Po<br>[209] | 85<br>At<br>[210] | 86<br>Rn<br>[222] |                  |
| 87<br>Fr<br>[223] | 88<br>Ra<br>[226] | 89<br>Ac<br>[227] | 104<br>Rf<br>[261] | 105<br>Db<br>[262] | 106<br>Sg<br>[266] | 107<br>Bh<br>[264] | 108<br>Hs<br>[277] | 109<br>Mt<br>[268] | 110<br>Ds<br>[281] | 111<br>Rg<br>[272] | 112<br>[285]      | 113<br>[284]      | 114<br>[289]      | 115<br>[288]      | 116<br>[292]      |                   |                   |                  |

|             |                   |                   |                   |                   |                   |                   |                   |                   |                   |                   |                    |                    |                    |                    |
|-------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|
| Lanthanides | 58<br>Ce<br>140.1 | 59<br>Pr<br>140.9 | 60<br>Nd<br>144.2 | 61<br>Pm<br>[145] | 62<br>Sm<br>150.4 | 63<br>Eu<br>152.0 | 64<br>Gd<br>157.2 | 65<br>Tb<br>158.9 | 66<br>Dy<br>162.5 | 67<br>Ho<br>164.9 | 68<br>Er<br>167.3  | 69<br>Tm<br>168.9  | 70<br>Yb<br>173.0  | 71<br>Lu<br>175.0  |
| Actinides   | 90<br>Th<br>232.0 | 91<br>Pa<br>231.0 | 92<br>U<br>238.0  | 93<br>Np<br>[237] | 94<br>Pu<br>[244] | 95<br>Am<br>[243] | 96<br>Cm<br>[247] | 97<br>Bk<br>[247] | 98<br>Cf<br>[251] | 99<br>Es<br>[252] | 100<br>Fm<br>[257] | 101<br>Md<br>[258] | 102<br>No<br>[259] | 103<br>Lr<br>[262] |

You may remove this page and use it as scratch paper and a cover sheet. If you need more scratch paper, you may get it from the proctor.

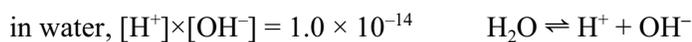
**Potentially useful information:**

$$C_1V_1 = C_2V_2 \quad 1\% \text{ w/v} = 1\text{g}/100 \text{ mL} = 1 \text{ g/dL}$$

$$1 \text{ ppm} = 1 \mu\text{g}/\text{mL} \quad 1 \text{ ppb} = 1 \text{ ng}/\text{mL}$$

$$6.022 \times 10^{23}$$

$$\text{pH} = -\log[\text{H}^+] \quad [\text{H}^+] = 10^{-\text{pH}}$$



**Check back over your exam and make sure you have completed all parts before turning in your paper!**

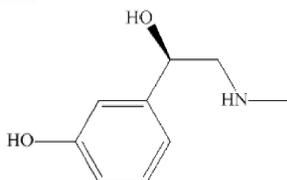
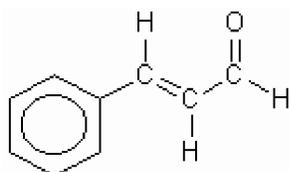
(MC score \_\_\_\_\_ FR score \_\_\_\_\_ Total raw \_\_\_\_\_ total % \_\_\_\_\_)

1. a. [10 pts] Write a balanced equation, with **appropriate** phase labels, for the **reaction between aqueous solutions of  $\text{CN}^-$  and  $\text{HCl}$** .

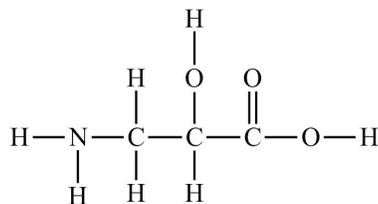
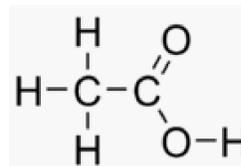
*(reminder--did you include phase labels?)*

b. [10 pts] Write a balanced equation, with **appropriate** phase labels, for the **combustion of hexene**.

*(reminder--did you include phase labels?)*

2. [6 pts] **Circle and clearly label all functional groups** in the structures below.

4. The structure below is an amphiprotic molecule.

a. [5 pts] Identify and **circle all acidic hydrogen atoms** in the structure (that is, any hydrogen atoms that can be donated to a base.)b. [2 pts] When the molecule functions as a **base**, where does  $\text{H}^+$  bond? **Show by adding  $\text{H}^+$  to the structure** in the appropriate place.3. [7 pts] Draw the structure of **2-methyl-3-octanol**.
5. [5 pts] **Sketch a hydrogen bonding interaction between the molecule below and a molecule of water.**

**Multiple Choice** [3 points each]. Choose the **best** answer and record it on your Scantron card. (Questions marked \*\* come directly from the assigned homework in the text or from worksheets in class.)

1 A sample contains 0.033 mol of aluminum ions. What is this value in **mmol** (millimoles)? (Chapter 1 review)

- A 0.000033 mmol      B 0.033 mmol      C 0.33 mmol  
D 33 mmol      E 33,000 mmol

2 A sample contains 0.42 mol of aluminum ions. How many grams of aluminum is this? (Chapter 2 review)

- A 0.016 g      B 0.088 g      C 11 g      D 27 g      E 64 g

3 Imagine that you are writing a chemical reaction equation that includes **elemental nitrogen** (under standard laboratory conditions). Which of these is the best representation of the formula of **elemental nitrogen**?

- A N      B N<sup>-</sup>      C N<sup>3-</sup>      D N<sub>2</sub>      E N<sub>2</sub><sup>3-</sup>

4 What is the most appropriate **phase label** for elemental nitrogen?

- A (s)      B (l)      C (g)      D (aq)

5\*\* Which of the following represents the **self-ionization of water**?

- A  $2\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq})$       B  $\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}(\text{g}) + \text{O}(\text{g})$   
C  $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$       D  $2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$   
E  $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$

6 Which reaction in #5 represents a **combustion** reaction?

7 Which reaction in #5 involves only breaking bonds, without forming any new bonds?

8 Which of these is the best representation of the formula of **calcium phosphate**?

- A CaP      B Ca<sub>2</sub>P<sub>3</sub>      C Ca<sub>3</sub>P<sub>2</sub>      D Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>      E Ca<sub>2</sub>(PO<sub>4</sub>)<sub>3</sub>

9 If some calcium phosphate is placed in water, which of these is the most appropriate phase label for the calcium phosphate in the resulting mixture?

- A (s)      B (l)      C (g)      D (aq)

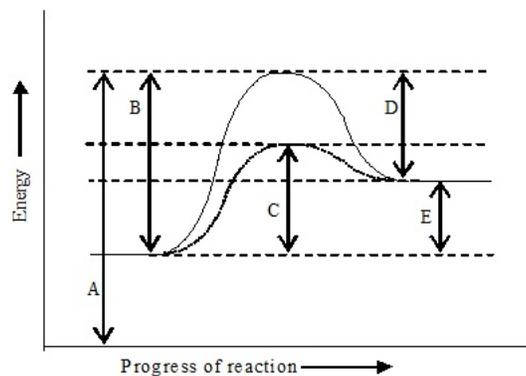
10 In the diagram at right, which arrow corresponds to the activation energy for the **uncatalyzed** reaction? (Use the letters marking the arrows.)

11 Which arrow indicates the value of  $\Delta H$  for the reaction?

12 Which of the following is an **endothermic** process?

- A forming a covalent bond
- C combusting methane
- E more than one of these

- B condensing water vapor
- D melting sodium chloride



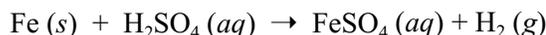
13 Balance the following reaction:



When this reaction is balanced with lowest-whole-number coefficients, what is the coefficient of Al?

- A 0
- B 1
- C 2
- D 3
- E 4

14 Iron reacts with sulfuric acid ( $\text{H}_2\text{SO}_4$ ) according to the following equation:



Which change will **decrease the activation energy** of the reaction?

- A Increasing the concentration of  $\text{H}_2\text{SO}_4$
- B Increasing the temperature
- C Grinding the iron metal into powder
- D Adding a catalyst

15 A chemist puts 2.00 g of  $\text{N}_2\text{O}_4$  into a container. Some of the  $\text{N}_2\text{O}_4$  breaks down into  $\text{NO}_2$ , forming an equilibrium mixture.



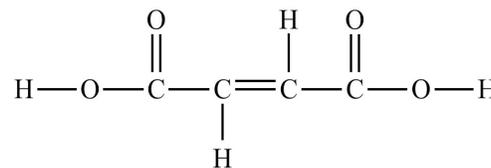
If the chemist then puts 2.00 g of  $\text{NO}_2$  into an identical container, which of the following statements will be true?

- A All of the  $\text{NO}_2$  will turn into  $\text{N}_2\text{O}_4$ .
- B Some of the  $\text{NO}_2$  will turn into  $\text{N}_2\text{O}_4$ .
- C None of the  $\text{NO}_2$  will turn into  $\text{N}_2\text{O}_4$ .

16 If you breathe rapidly and shallowly, expelling  $\text{CO}_2$  from your lungs more rapidly than usual, what effect will this have on your blood?

- A Your blood will become more acidic.
- B Your blood will become more basic.
- C Your blood will become amphiprotic.
- D Your blood will become hypertonic.
- E Your blood will become isotonic.

- 17 What is the **pH** of a solution with  $[H^+] = 0.044 \text{ M}$ ?
- A  $2.2 \times 10^{-13}$       B 0.044      C 1.36      D 2.49      E 11.51
- 18 What is the **[OH<sup>-</sup>]** in a solution with  $[H^+] = 0.044 \text{ M}$ ?
- A  $2.2 \times 10^{-13}$       B 0.044      C 1.35      D 2.49      E 11.51
- 19 Which species is the **conjugate acid of  $HPO_4^{2-}$** ?
- A  $H^+$       B  $H_3PO_4$       C  $H_2PO_4^-$       D  $PO_4^{3-}$       E  $OH^-$
- 20 Which of these species is **diprotic**?
- A  $H^+$       B  $H_3PO_4$       C  $H_2PO_4^-$       D  $PO_4^{3-}$       E  $OH^-$
- 21 Which of the species is **amphiprotic**?
- A  $H^+$       B  $H_3PO_4$       C  $H_2PO_4^-$       D  $PO_4^{3-}$       E  $OH^-$
- 22 In a tertiary alcohol, **how many H atoms** are attached to the carbon atom with the alcohol group?
- A 0      B 1      C 2      D 3      E it's variable
- 23 What product is formed in the **hydration** of 2-butene? (Hint: write out the reaction, using structures!)
- A 1-butene      B butane      C 2-butanol      D a mixture of 2-butanol and 3-butanol
- 24 Give the correct, systematic name for this molecule:  $CH_3CH_2CH_2CH_2CH_2OH$
- A pentane hydroxide      B 1-pentanol      C 5-pentanol      D 5-pentanal      E pentanoic acid
- 25 The structure shown at right is fumaric acid, a molecule found in many fruits. Which molecular formula most accurately represents the acidic nature of this molecule?



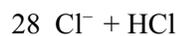
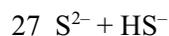
- A  $C_4H_4O_4$       B  $HC_4H_3O_4$       C  $H_2C_4H_2O_4$
- D  $H_3C_4HO_4$       E  $H_4C_4O_4$

Turn your Scantron card over and start with #26. The remaining questions earn 1 point each.

Decide whether each combination below, when dissolved in aqueous solution, will form a buffer solution or not.

B Buffer

C No buffer

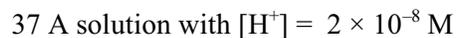
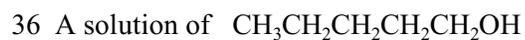
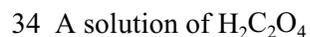
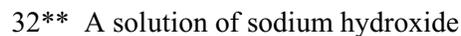


For the next few problems, assign each solution as **acidic**, **basic** or **neutral** as appropriate.

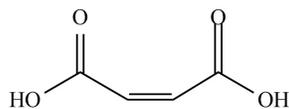
A acidic

B basic

C neutral



38



39

