CHAPTER 1

Multiple Choice

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2. 1 8 3
3. 3 9 4
4. 4 10 3
5. 1 11 3
6. 3 12 1
7. 1 9 4
8. 4 10 4
9. 1 11 2
10. 1 12 4
11. 2 13 4
12. 2 14 4
13. 2 15 2
14. 3 16 2

1. a. Cd and He (1 point for each element)
b. Yes. (1 point)
The yellow-green line in X is not in Cd or He. (1 point)
c. No. (1 point)
The spectral lines in H are absent in X (1 point)
2. a. 3 protons, 4 neutrons, 3 electrons (1 point each)
b. 2 (1 point)

3. a. $0.200 \times 42.0 + 0.800 \times 44.0 = 43.6$
   (1 point for correct method)
   (1 point for correct answer)
b. The isotopes are uniformly mixed in nature. (1 point)

4. a. Strontium or Sr (1 point)
b. excited state (1 point)
c. release (1 point)
The forth energy level can hold 8 electrons so one of the fifth energy level electrons will drop down which gives off energy (1 point)
d. $\text{Sr}^{\text{++}}$ — The two dots do not have to be together.
   — Do not take off again if they missed question “4a”.

5. a. 4 b. 2 c. 3 d. 1 (1 point each)

6. John Dalton JJ Tompson Ernest Rutherford Neils Bohr

7. Chlorine always has 17 protons as a neutral atom. (1 point)
   By finding the atomic number of chlorine, you would know the number of protons because the atomic number is equal to the number of protons. (1 point)
CHAPTER 2

Multiple Choice

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1. a. G  b. B  c. F  d. B  e. G  f. Noble gases are not considered chemically reactive. (1 point each)

   (1 point each part. Accept any of the three answers in b.)

3. a. & b.

   Group 17

   Period 6

   c. Accept any answer between 812 and 950 kJ/mole (1 point)
   d. Group 17 graph extrapolates to 800; Period 6 interpolates to 930.
      It can't be below Po at 812. Interpolation is more accurate than extrapolation.
      (1 point for either answer)

4. (1 point each) a. Group 2  b. 2  c. Ra  d. either F, Br, I, or At (any halogen)

5. a. nuclear charge (number of protons) (1 point)
    principal energy level of valence electrons (distance from nucleus) (1 point)
    electron cloud effect of inner (non-valence) electrons (1 point)
    b. Increase in principal energy level (distance) and electron cloud effect exceeds increased nuclear charge. (1 point)
    c. Increase in nuclear charge. (1 point)
2. a. $159.6 \text{ u}$ It is not used in a calculation, so different numbers of significant figures can be used. (1 point)

b. $\frac{2 \times 55.8 \text{ u} \ Fe}{160. \text{ u} \ Fe_2O_3} \times 100\% = 70.0\% \ Fe$ (1 point for method, 1 point for correct answer)

c. $0.349 \times 500. \text{ g} = 174 \text{ g Fe}$ or $\frac{55.8 \text{ u}}{160. \text{ u}} = \frac{x}{500. \text{ g}}$ (1 point for method, 1 point for answer, units, and significant figures)

3. a. in 100.0 g sample

$\frac{14.3 \ % \ H}{1.00 \ g \ / \ mol} = 14.3 \ mol \ H$ (1 point for 14.3 and 7.14 mol, 1 point for answer)

$\frac{85.7 \ % \ C}{12.0 \ g \ / \ mol} = 7.14 \ mol \ C$

$\frac{14.3 \ mol \ H}{7.14 \ mol \ C} = 2$ empirical formula $= \text{CH}_2$

b. $\frac{84.0 \ u}{12 + 2 \ u} = 6.0 \ 6 \ (\text{CH}_2) = C_6 \text{H}_{12}$ (1 point)

4. a. 10. molecules $\times \frac{4}{5} = 8$ molecules $H_2O$ (1 point for method, 1 point for answer for each part)

b. $3.0 \ mol \times \frac{3}{1} = 9.0 \ mol \ CO_2$

c. $11 \ g + 40. \ g = x + 18 \ g. \quad x = 33 \ g. \ CO_2$
5. \[
\begin{array}{c}
\text{H}_2\text{O} \\
\text{left over } \text{O}_2
\end{array}
\]  
(1 point for using proper structures for \(\text{H}_2\text{O}\) and \(\text{O}_2\))
(1 point each for correct number of \(\text{H}_2\text{O}\) and left over \(\text{O}_2\))

6. a. 0.178 mol  
   (1 point for answer, 1 point for correct significant figures)
   b. 3  
   (1 point)

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**CHAPTER 4**

**Multiple Choice**

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**Constructed Response**

1. Strong hydrogen bonds form between a hydrogen atom of one molecule and an oxygen atom of a different molecule holding the molecules together tightly.

2. a. ionic (or electrovalent)  
   (1 point)
   b. K⁺ and N⁻ and H⁻  
   (1 point)
   c. K⁺  
   (1 point)

3. a. covalent or polar covalent  
   (1 point)
   b. N⁻ and H⁺  
   (1 point)
   c. H⁻  
   (1 point)
4. Neon has all eight of its electrons as an element, the maximum and stable number. Bonding would either add to or subtract from eight electrons and be less stable

(1 point for formula, 1 point for stable octet, 1 point for effect bonding makes to octet.)

5. a. any metal

b. 

c. Nearly empty valence energy level allows close arrangement and high density. (1 point). Low attraction for electrons and close proximity of many atoms to valence electrons makes it easy for electrons to pass from one atom to another. (1 point)

6. \( \text{N} = \text{N} \) is non-polar (1 point) because the two atoms attract electrons equally (1 point)

\( \text{H} \quad \text{O} \quad \text{O} \quad \text{H} \)

is polar (1 point) because there is a large difference in attraction for electrons (electronegativity) between H and O and the molecule is not symmetrical. (1 point)

\( \text{O} = \text{C} = \text{O} \) is non-polar (1 point). Although C and O have a large difference in attraction for electrons (electronegativity) the molecule is symmetrical so the polar bonds cancel each other. (1 point)

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**CHAPTER 5**

**Multiple Choice**

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1. solid

2. liquid

3. gas

1 point each
2. polar solvent  non-polar solvent  

(1 point each diagram)

The negative ends of solvent attract positive ends of solute to pull it off. The non-polar solvent is not strongly attracted so it does not.  (1 point)

3. 

(a) 

(b) 

(1 point each graph for volume on y axis and labeling axes. 1 point for correct plotting.)

3. 

c. \( P \times V = 6.44 \times 10^3 \text{mL} \cdot \text{atm} \), or volume is inversely proportional to pressure.  (1 point)

d. \( \frac{V_2}{T_2} = 2.7 \frac{\text{mL}}{\text{K}} \) or volume is directly proportional to kelvin temperature.  (1 point)

e. \( \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \)  
\[ V_2 = V_1 \times \frac{P_1}{P_2} \times \frac{T_2}{T_1} = 891 \text{mL} \times \frac{0.790 \text{ atm}}{0.700 \text{ atm}} \times \frac{373 \text{K}}{353 \text{K}} = 1060 \text{mL} \]

(1 point for method, 1 point for answer)

4. 

(a) 

(b) 4.0 min.

c. \[ q = m \cdot C \cdot \Delta T \]
\[ = 100. q \times 1.00 - \frac{J}{g \cdot \text{K}} \times 24 \text{K} = 2400 \text{J} \]

d. b
e. pure (1 point) Has a constant freezing temperature. (1 point)
f. Begins freezing at a lower temperature (lower plateau) or the freezing temperature slowly drops.

5. a. $M = \frac{5.00g}{\frac{111g/mol}{2.00 L}} = 0.0225M$

   (1 point for right answer, 1 point for right method and significant figures.)

   b. ppm = \frac{g \text{ of solute}}{g \text{ of solution}} \times 10^6 = \frac{5.00}{2000} \times 10^6 = 2.50 \times 10^3 \text{ ppm}

   (1 point for right answer, 1 point for right method and significant figures.)

**CHAPTER 6**

**Multiple Choice**

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**Constructed Response**

b. 5 kJ/mol (1 point)

c. exothermic (1 point)

d. the peak (activation energy) (1 point)

e. 17 kJ/mol (1 point)

2. a. equilibrium. Closed system. All reactants and products are present in constant amounts. A saturated solution.

b. not equilibrium. Reactant (alcohol) is gone.

c. not equilibrium. Open system. All alcohol will evaporate.

d. not equilibrium. Concentrations are changing.

   (1 point for answer, 1 point for reason)

3. a. Molecules move faster, collide more frequently and with more energy.

b. Increases surface area of solid to expose more molecules to collision.

c. More molecules in a volume will collide more frequently. (1 point each part)

4. a. (3) Liquid to gas increases entropy, and energy decreases. (1 point for answer, 1 point for reason.)

b. (4) Gas to liquid decreases entropy, and energy increases. (1 point for answer, 1 point for reason.)
5. 1. Increase concentration of SO₂ (g) (1 point for each of any three)
   2. Increase concentration of O₂ (g)
   3. Increase pressure of system.
   4. Raise the temperature a little to increase rates, but not too high since heat shifts the equilibrium away from products.
   5. Remove SO₂(g) as soon as possible.

### CHAPTER 7

#### Multiple Choice

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#### Constructed Response

1. **a.** Addition (1 point)

   \[ R-C=CH_2 + H_2 \rightarrow R-C-C=CH_2 \] (1 point)

   **b.** Saturation increases the molecular weight enough to solidify the oil, making it smoother and more uniform. By removing double bonds, the oil becomes less reactive making a longer shelf-life. (1 point for either answer)

2. \[ \text{butanoic acid} \rightarrow \text{ethanol} \]

   \[ \text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_3+\text{H}_2\text{O} \]

   (1 point for each formula, 1 point for each reactant named)

3. **a.**

   \[ \text{ethanol} \]

   **b.**

   \[ \text{dimethyl ether} \]

   **c.**

   \[ \text{ethyl amine} \]

   **d.**

   \[ \text{dimethyl amine} \]

   (1 point for each correct isomer, 1 point for each correct name. Subtract 1 point for each incorrect isomer. Do not go below 0 points for each part.)
4. a. 
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{C} \cdots \text{C} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

b. 
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{C} \cdots \text{C} \\
\text{O} \cdots \text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

c. 
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{C} \cdots \text{C} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

d. 
\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{C} \cdots \text{C} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

(1 point each)

5. 1. too many hydrogens on interior C of double bond
2. too many bonds to C with –COOH, or acid functional groups must be at the end of the chain.
3. N needs another H
   (1 point for each mistake. -1 for each wrong change.)

6. 1. e 5. f
2. c 6. a
3. b 7. d
4. g

---

**CHAPTER 8**

**Multiple Choice**

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**Constructed Response**

1. a. \( \text{Ca(s) + 2 Ag}^+\text{(aq)} \rightarrow 2 \text{Ag(s) + Ca}^{2+}\text{(aq)} \) (1 point correct products, 1 point balance.)

b. no reaction (2 points)

c. \( \text{2Al(s) + 3Fe}^{2+}\text{(aq)} \rightarrow 3\text{Fe(s) + 2 Al}^{3+}\text{(aq)} \) (1 point correct products, 1 point balance.)

2. D most
   C B
   A least

(Allow 1 point if only one element is out of order.
2 points if all are in order.)

---

9
3. a. (1 point for wire, 1 point for saltbridge.)

![Diagram of a wire connecting a copper and a lead electrode through a salt bridge.]

b. a (1 point)
c. \( \text{Cu}^{2+} + 2e^- = \text{Cu}(s) \) (1 point)
d. \( \text{Pb} \) (1 point)

4. a. negative (1 point each part)
b. cathode
c. \( \text{Ag}^+ + e^- \rightarrow \text{Ag}(s) \)
d. \( 2\text{Cl}^- \rightarrow \text{Cl}_2(g) + 2e^- \)
e. left

5. a. Paint separates the iron from material being reduced. Electrons can’t flow through paint easily.
b. The zinc is more easily oxidized than iron, so the zinc loses electrons instead of the iron.
c. Corrosion is oxidation, the loss of electrons. If electrons from a battery are added, it drives the equilibrium \( \text{Fe} = \text{Fe}^{2+} + 2e^- \) to the left. (1 point each part)

**CHAPTER 9**

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### Constructed Response

1. a. 1
   b. 3
   c. 1
   d. 2
   e. 2
   f. 3
   g. 4
   h. 4
   i. 1
   (1 point each)

2. a. \( M_{\text{H}_2} + V_{\text{H}_2} = M_{\text{OH}^-} V_{\text{OH}^-} \)

\[
V_{\text{OH}^-} = V_{\text{H}_2} \frac{M_{\text{H}_2}}{M_{\text{OH}^-}} = 25.0 \text{mL} \times \frac{0.350 \text{M}}{0.535 \text{M}} = 16.4 \text{mL}
\]

**SCORE:** 2 points if work, significant figures, mL, and answer are correct
1 point if answer is correct

b. \( \text{Ba(OH)}_2 \) has twice as many \( \text{OH}^- \) as \( \text{KOH} \) so it would require \( \frac{1}{2} \) as much volume (8.40mL). (1 point)
3. a. \( \text{H}_2\text{SO}_4 + 2\text{KOH} \rightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O} \) 
   (1 point for correct formulas,  
   1 point for correct balancing.)

b. exothermic  
   (1 point)

4. methyl orange.  (1 point) It changes in a range of 3.2 - 4.4, the lowest of any indicator on the chart. The stronger the acid, the lower the pH. (1 point)

5. (1) To separate test tubes add a different acid - base indicator, such as Table M of the Reference Tables for Physical Setting/Chemistry 
   (2) Use pH meter. 
   (3) Add some to a base. If lots of heat is generated, it is an acid. Add some to an acid. If lots of heat is generated, it is a base.  
   (Any safe two methods is 2 points, 1 point for each. If any unsafe method is suggested (like tasting) give 0 points for the question.)

### CHAPTER 10

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#### Constructed Response

1. a. \( {}^0\text{e} \)  (2) \( {}^{94}_{36}\text{Kr} \) 
   (1 point each)
   (3) \( {}^{14}_{7}\text{N} \)  (4) \( {}^4_{2}\text{He} \)

b. 4  
c. 2  (1 point each)

d. 1

e. 3

2. a. \( {}^2_{85}\text{He} + {}^{216}_{85}\text{At} \)  b. \( {}^0_{-1}\text{e} + {}^{16}_{8}\text{O} \)  c. \( {}^0_{+1}\text{e} + {}^{37}_{19}\text{K} \)  
   (1 point each part)

3. a. *radioactive dating*  
   - treating of cancer and other diseases  
   - tracing chemical processes  
   - non-invasive preservation of food  
   - smoke alarms  
   (2 points for any two benefits)

b. *exposure can cause radiation sickness, cancer or genetic mutations*  
   - long term storage and disposal  
   - nuclear accidents  
   (2 points for any two risks)

4. For fusion to occur, nuclei of atoms must collide and join together. But all nuclei have positive charge and repel each other. To make them collide, they must get moving very fast and be very hot. The temperatures would melt any materials we have. Some energy other than heat is needed to give the nuclei enough to collide.  
   (1 point - nuclei are positive and repel, 1 point - extreme temperatures needed to overcome repulsions.)

5. a. \( {}^{137}_{55}\text{Cs} \rightarrow {}^0_{-1}\text{e} + {}^{137}_{56}\text{Ba} \)  
   (1 point each product)
b. 

<table>
<thead>
<tr>
<th>Mass</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>original Cs = 0.040 g.</td>
<td>0</td>
</tr>
<tr>
<td>.020 g.</td>
<td>30 years (1 half-life)</td>
</tr>
<tr>
<td>current Cs</td>
<td>.010 g.</td>
</tr>
<tr>
<td></td>
<td>60 years (2 half-lifes)</td>
</tr>
</tbody>
</table>

(1 point)

c. It assumes the rate of decay (or half-life) is uneffected by temperature or chemical or physical effects over time. (1 point)

**APPENDIX A**

1. $2.4388 \times 10^4$
2. $3.6 \times 10^{-3}$
3. a. 3  b. 2  c. 2  d. 4  e. 4  f. 2
4. a. 0.89 cm$^2$  b. 149.6 cm
5. 12.3%
6. a. temperature  
   
   ![Graph showing pressure (kPa) vs. temperature (°C)]
   
c. yes  
   d. no  
   e. 2.5 kPa/°C  
   f. 697 kPa  
   g. -280°C  
   h. $P = 2.5 \text{kPa}/°C \cdot T + 697 \text{kPa}$

**APPENDIX C**

1. 1.69L  
2. 1.19 atm  
3. 74.3 mL  
4. 1700 J  
5. 4.4 g. 
6. 270 J 
7. 2 μJ 
8. $4.18 \times 10^3$ L 
9. 4.5 × 10$^6$ cm 
10. joule 
11. liter 
12. pascal (Pa) 
13. 4 
14. 3 
15. 2 
16. 4 
17. 1 
18. 3 
19. 2 
20. 2 
21. 2 
22. 4 
23. 4 
24. 3 
25. 3 
26. 79°C 
27. ethanoic acid 
28. 45°C 
29. 4 
30. 2 
31. 91.3 kJ 
32. yes 
33. no 
34. Co + Mg (NO$_3$)$_2$ 
35. pink 
36. 1-8 
37. 2 
38. 4 
39. 1 
40. 3 
41. 2 
42. 3 
43. propane 
44. 2 - butene 
45. 3 - heptyne 
46. 
47. butanal 
48. 2 - pentanol 
49. 2,3 - dibromopentane 
50. ethanamine 
51. 
52. ketone 
53. F 
54. 3 
55. 419 kJ/mol 
56. Br and Hg 
57. $2.08 \times 10^{-10}$ m 
58. 17.4% 
59. 0.0500 g. 
60. 693 kPa 
61. 33.4 kJ 
62. 19 mL
**Additional Constructed Response Questions**

1. a. When the log burns, some of its heat is absorbed to evaporate the water. Since there is more water in the green log, it would remove more heat.  
   (1 point)

   b. \(10.0 \text{ kg} \times 0.650 = 6.50 \text{ kg cellulose} = 6500 \text{ g}\) (assume \(\text{C}_6\text{H}_{12}\text{O}_6\))

   \[
   \frac{6500}{180 \text{ g/mol}} \times (-2804 \text{ kJ/mol}) = -1.01 \times 10^5 \text{ kJ from combustion} \quad (1 \text{ point})
   \]

   \[10.0 \text{ kg} \times 0.350 = 3.5 \text{ kg water} = 3500 \text{ g}.
   \]

   \[3500 \text{ g} \times 2.259 \text{ kJ/g} = 7910 \text{ kJ to evaporate water} \quad (1 \text{ point})
   \]

   \[-101,000 \text{ kJ} + 7,910 \text{ kJ} \]

   \[-93,000 \text{ kJ} \quad (1 \text{ point})\]

2. a. All three compounds have \(-\text{OH}\), as does water (HOH). They all hydrogen bond to the water, which is a strong intermolecular force.  
   (1 point)

   b. 1,2,3-propanetriol has the most \(-\text{OH}\) (1 point), so it has the greatest amount of hydrogen bonding. Since these molecules have the greatest attractions for each other, 1,2,3-propanetriol has the highest boiling point.  
   (1 point)

3. a. powdered gypsum, goggles and apron, crucible, crucible tongs, ring and ringstand, wire triangle, bunsen burner, balance, matches or flint striker. (deduct 1 point for every two items missing)

   b. The goggles and apron are to be worn by the student. 
   The powdered gypsum is placed in the crucible and massed on the balance. 
   The massed crucible with the gypsum is placed in the wire triangle on the ring of the ringstand. 
   The bunsen burner (lit by matches or striker) is used to heat the bottom of the crucible. 
   The crucible tongs are used to pick up the hot crucible to be massed again on the balance. (2 points if all but one item is correctly used.) (1 point if all but two items are correctly used.)

4. a. 226

   \(\text{Ra} \rightarrow 4 \text{ He} + 222 \text{ Rn} \quad (1 \text{ point})\)

   c. see diagram

   d. Must deflect up or down from answer C. See diagram for one possibility (1 point)

   e. See diagram (1 point)
5. 1. Put on the goggles and apron.
2. Make 100.0 mL of 2.0 M NaOH by weighing 8.00 g of NaOH(s).
3. Transfer the NaOH(s) to the volumetric flask, and add deionized water to the 100.0 mL mark. Shake to dissolve.
4. Place both burets into the buret holder on the ringstand. (This step can come after Step 1 if desired.)
5. Add the HCl(aq) to one buret and NaOH(aq) to the other. (?Bleeding? should be done, but don’t take off points if neglected.)
6. Add either HCl(aq) or NaOH(aq) from the buret to a convenient sized Erlenmeyer (titrating) flask, and add a drop of phenolphthalein.
7. Titrate with the other solution until one additional drop changes the color of the solution.
8. Record the volumes to the greatest accuracy possible. (There should be at least 10.0 mL of each solution, but don’t take off if the student fails to mention this.
9. Repeat the titration two more times. (4 points) Deduct 1 point for each step misplaced or omitted.

6. a. C (1 point)  b. A (1 point)  c. B (1 point)
   d. The average densities determined by the three students were:
      A: 7.80 ± .25 g/cm³  B: 8.00 ± .420 g/cm³  C: 7.6 ± .1 g/cm³
      C had the greatest precision because the average deviation was only ± .1 g/cm³
      A had the greatest accuracy because 7.80 is closest to the reference table value
      of 7.874 g/cm³.
      B has the most significant figures (4) (1 point for each explanation)

7. a. smaller particle size has more surface area for reactants to collide and stick more frequently. (1 point)
   b. \[ H_2C = CHCH_3 + H_2 \rightarrow CH_3CH_2CH_3 \] (1 point for reactants and products
      and 1 point for catalyst)
   c. addition or hydrogenation (1 point for either)
   d. [Diagram of reaction coordinate]
      (1 point for MgO curve)
      (1 point for Al₂O₃ curve)

8. a. chemical – unreactive noble gas (1 point)
    physical – radioactive, unstable, high density, low boiling (melting) point
    (1 point for any correct answer)
   b. \[ ^{84}_{36}Kr + ^{206}_{82}Pb \rightarrow ^{290}_{118}Uuo \] (1 point for mass number 290 and 1 point for the rest of the equation)
   c. \[ ^4_{2}He or alpha \] (1 point)
      \[ ^{290}_{118}U \rightarrow ^4_{2}He + ^{238}_{116}Uuh \] (1 point for correct reaction using their answer from Part b)
   d. 3 (1 point)
   e. 1 (1 point)
   f. The experiment was not reproducible. (1 point)