1. A 1.0 g organic compound sample produced 2.36 grams of CO\(_2\) and 0.640 grams of H\(_2\)O during combustion analysis. If the hydrocarbon has a molar mass between 110 and 114 g/mol, what is its molecular formula?

(1) C\(_3\)H\(_6\) (2) C\(_3\)H\(_4\)O (3) C\(_6\)H\(_{12}\)O\(_2\) (4) CH\(_2\)O\(_3\) (5) C\(_4\)H\(_8\)

2. A 6.00 M solution of dye is diluted by taking 13.00 ml of it and adding enough water to make 100.0 ml solution. Then, 18.00 ml of that solution is diluted to a volume of 500.0 ml. What is the concentration of the diluted dye?

(1) 0.780 M (2) 0.0281 M (3) 0.0400 M (4) 0.00281 M (5) 0.0780 M

3. Which of the following is the net ionic equation for the reaction between Ba(OH)\(_2\) and CuSO\(_4\)?

(1) Ba(OH)\(_2\) (aq) + CuSO\(_4\) (aq) → BaSO\(_4\) (s) + Cu(OH)\(_2\) (s)
(2) Ba(OH)\(_2\) (aq) + CuSO\(_4\) (aq) → Ba\(_2\)SO\(_4\) (aq) + 2OH\(^-\) (aq) + Cu\(_2\)OH\(_2\) (aq) + SO\(_{4}\)\(^2-\) (aq)
(3) Ba\(_2\) (aq) + 2OH\(^-\) (aq) + Cu\(_2\) (aq) + SO\(_{4}\)\(^2-\) (aq) → BaSO\(_4\) (s) + Cu(OH)\(_2\) (s)
(4) Ba\(_2\) (aq) + SO\(_{4}\)\(^2-\) (aq) → BaSO\(_4\) (s)
(5) 2OH\(^-\) (aq) + Cu\(_2\) (aq) → Cu(OH)\(_2\) (s)

4. How many grams of precipitate will form if excess KCl is added to 1.46 L of 0.913 M AgNO\(_3\)?

(1) 1.33 g (2) 1.91 \times 10^2 g (3) 2.30 \times 10^2 g (4) 3.00 \times 10^2 g (5) 6.90 \times 10^2 g

5. The density of fresh milk (as it comes from a yak) is found to be 83.65 lbs per cubic foot. Converted to SI units this translates into:

(1) 83.54 kg/m\(^3\) (2) 1997.0 kg/m\(^3\) (3) 1028 kg/m\(^3\) (4) 1340 kg/m\(^3\) (5) 4998 kg/m\(^3\)
6. Identify the acid in the following acid-base reactions:

\[ \text{HCO}_3^- (aq) + \text{H}_2\text{O} (l) \rightarrow \text{H}_2\text{CO}_3 (aq) + \text{OH}^- (aq) \]
\[ \text{HCO}_3^- (aq) + \text{NH}_3 (aq) \rightarrow \text{NH}_4^+ (aq) + \text{CO}_3^{2-} (aq) \]

(1) \text{HCO}_3^- and \text{HCO}_3^-  
(2) \text{H}_2\text{O} and \text{NH}_3  
(3) \text{HCO}_3^- and \text{NH}_3  
(4) \text{H}_2\text{O} and \text{HCO}_3^-  
(5) These are not an acid-base reactions

7. \text{MnO}_2 in a solution of HCl results in the formation of chlorine gas, as follows:
\[ \text{MnO}_2 (s) + 4\text{HCl} (aq) \rightarrow \text{MnCl}_2 (aq) + \text{Cl}_2 (g) + 2\text{H}_2\text{O} (l). \]
During this reaction, which of the following takes place?
(1) \text{Mn} ion is oxidized  
(2) Chlorine ion is reduced to \text{Cl}_2  
(3) \text{Cl} acts as the reducing agent  
(4) \text{MnO}_2 acts as the oxidizing agent  
(5) all of the above take place

8. A mass of 1.37 g of an unknown gas is introduced into an evacuated 1.70 L flask. If the pressure in the flask is 619 torr at 98°C, which of the following gases might be in the flask?
(1) \text{CH}_4  
(2) \text{C}_2\text{H}_6  
(3) \text{C}_2\text{H}_2  
(4) \text{C}_3\text{H}_8  
(5) \text{C}_4\text{H}_{10}

9. A mixture of \text{Xe}(g) and \text{O}_2(g), formed by the complete decomposition of \text{XeO}_4(g), is collected over water at 42°C at a total pressure of 760 mmHg. If the vapor pressure of water is 40 mmHg at 42°C, what is the partial pressure of \text{O}_2?
(1) 255 mmHg  
(2) 380 mmHg  
(3) 485 mmHg  
(4) 518 mmHg  
(5) 720 mmHg

10. A red laser emits light pulses of 675 nm and 0.528 J/pulse. How many photons are produced per pulse?
(1) 1.793 \times 10^{18}  
(2) 1.50 \times 10^{36}  
(3) 6.55 \times 10^{-19}  
(4) 2.73 \times 10^{-37}  
(5) 2.95 \times 10^{-19}
11. When 65.0 ml of 0.200 M AgNO₃ and 50.0 ml of 0.100 M CaCl₂, both at 25.0°C, are reacted in a coffee-cup calorimeter, the temperature of the reacting mixture increases to 26.0°C. Calculate ΔH in kJ per mole of AgCl produced. Assume the density of the solution is 1.05 g/ml and the specific heat capacity of the solution 4.20 J/g°C.
(1) 44 kJ/mol (2) 5.0715 kJ/mol (3) −44.0 kJ/mol (4) −5.0715 kJ/mol (5) −128 kJ/mol

12. Steam reforming of methane is the most common method of industrially producing commercial bulk hydrogen. At high temperatures (700 - 1100°C), and in the presence of a catalyst, steam reacts with methane according to the following equation:
H₂O(g) + CH₄(g) → 3 H₂(g) + CO(g).
Calculate the standard enthalpy change for this reaction. Potentially helpful information:
CH₄(g) + 2 O₂(g) → CO₂(g) + 2 H₂O(g) \( \Delta H_{\text{rxn}}^\circ = -838.0 \text{kJ/mol} \)
CO(g) + ½ O₂(g) → CO₂(g) \( \Delta H_{\text{rxn}}^\circ = -238.0 \text{kJ/mol} \)
H₂(g) + ½ O₂(g) → H₂O(g) \( \Delta H_{\text{rxn}}^\circ = -241.8 \text{kJ/mol} \)
(1) −1317.5 kJ/mol (2) −596.2 kJ/mol (3) −358.2 kJ/mol (4) +125.4 kJ/mol (5) +838.0 kJ/mol

13. The following graph shows the kinetic curves for the reaction
I₂(aq) + 2 S₂O₃²⁻ (aq) → S₄O₆²⁻(aq) + 2 I⁻(aq).

Which curve is S₂O₃²⁻ and which curve is for S₄O₆²⁻?
(1) S₂O₃²⁻: the asterisks (✴)
S₄O₆²⁻: the circles (○)
(2) S₂O₃²⁻: the triangles (△)
S₄O₆²⁻: the circles (○)
(3) S₂O₃²⁻: the circles (○)
S₄O₆²⁻: the triangles (△)
(4) S₂O₃²⁻: the diamonds (◊)
S₄O₆²⁻: the triangles (△)
(5) Since the kinetic curve is at equilibrium, any curve can represent either
14. Rate data have been determined at a particular temperature for the reaction 
\[ 2 \text{NO(g)} + \text{Cl}_2(g) \rightarrow 2 \text{NOCl(g)} \]. The numerical value of the rate constant \( k \) is ______.

<table>
<thead>
<tr>
<th>Exp</th>
<th>[NO] (M)</th>
<th>[Cl(_2)] (M)</th>
<th>Rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0300</td>
<td>0.0100</td>
<td>3.4x10(^-4)</td>
</tr>
<tr>
<td>2</td>
<td>0.0150</td>
<td>0.0100</td>
<td>8.5x10(^-5)</td>
</tr>
<tr>
<td>3</td>
<td>0.0150</td>
<td>0.0400</td>
<td>3.4x10(^-4)</td>
</tr>
</tbody>
</table>

(1) 0.38  
(2) 0.57  
(3) 1.1  
(4) 3.4  
(5) 38

15. Arrange the following salts in order from weakest to strongest lattice energy (smallest to largest magnitude of lattice energy): Lithium fluoride, calcium nitrate, magnesium nitrate, rubidium fluoride

(1) rubidium fluoride < lithium fluoride < calcium nitrate < magnesium nitrate
(2) magnesium nitrate < calcium nitrate < lithium fluoride < rubidium fluoride
(3) rubidium fluoride < magnesium nitrate < calcium nitrate < lithium fluoride
(4) calcium nitrate < magnesium nitrate < rubidium fluoride < lithium fluoride
(5) magnesium nitrate < calcium nitrate < rubidium fluoride < lithium fluoride

16. What is the molecular geometry for SO\(_4\)?

(1) trigonal bipyramidal  
(2) tetrahedral  
(3) trigonal pyramidal  
(4) trigonal planar  
(5) square pyramidal

17. How many sigma and pi bonds, respectively, are in HO\(_2\)CC(O)CH\(_2\)CO\(_2\)H?

(1) 12 σ, 3 π  
(2) 12 σ, 1 π  
(3) 11 σ, 4 π  
(4) 10 σ, 2 π  
(5) 9 σ, 1 π
18. Consider the following vapor pressure curve diagram. Identify which of the curves correspond to CH₄, CH₃Cl, and CH₃I. What is the approximate normal boiling point of CH₃Cl?

(1) 20°C  
(2) 40°C  
(3) 60°C  
(4) 80°C  
(5) 100°C

19. According to the molecular orbital (MO) treatment of the CO molecule, what are the bond order and the number of unpaired electrons in CO, respectively? The valence molecular orbital sequence for CO is:

σ₂s, σ*₂s, π₂px = π₂py, σ₂p, π*₂px = π*₂py, σ*₂p

(1) 2, 2  
(2) 3, 2  
(3) 3, 1  
(4) 1.5, 2  
(5) 2.5, 1

20. Which of the following aqueous solutions will have the lowest freezing point?

(1) 0.10 m KOH  
(2) 0.15 m CH₃OH  
(3) 0.05 m BaCl₂  
(4) 0.05 m NH₄NO₃  
(5) 0.10 m K₂SO₄

21. Metallic gold (Au) crystallizes in the face-centered cubic lattice with an edge length of 407 pm. From this information, estimate the density of gold in g/cm³.

(1) 4.85 g/cm³  
(2) 15.9 g/cm³  
(3) 19.4 g/cm³  
(4) 12.5 g/cm³  
(5) 9.71 g/cm³