1. Which of the following correctly lists compounds by decreasing boiling point?
(1) CH₃OH, H₂O  (2) CH₃CH₂CH₂CH₃, CH₃CH₃  (3) He, HCl  (4) LiF, BaS

2. Which of the following compounds has the greatest lattice energy?
(1) CaF₂  (2) BeF₂  (3) NaBr  (4) Rb₂O  (5) K₂SO₄

3. An experiment was run with differing concentrations of reactants, and the rate of reaction was recorded:

<table>
<thead>
<tr>
<th>A (mol/L)</th>
<th>B (mol/L)</th>
<th>C (mol/L)</th>
<th>Rate (mol/Ls)</th>
</tr>
</thead>
<tbody>
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<td>0.04</td>
<td>0.08</td>
<td>0.04</td>
<td>0.0009984</td>
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<td>0.04</td>
<td>0.02</td>
<td>0.04</td>
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</table>

What is the rate constant for this reaction?
(1) 7.8 L²mol⁻²s⁻¹  (2) 4.9 L²mol⁻²s⁻¹  (3) 2.8 L²mol⁻²s⁻¹  (4) 3.1 L²mol⁻²s⁻¹  (5) 9.2 L²mol⁻²s⁻¹

4. A 5 L container at 25°C is filled with water vapor until the pressure inside the container reaches 3 atm. How many moles of Hydrogen atoms are in the container?
(1) .61 mol  (2) 6.1 mol  (3) 1.2 mol  (4) 3.7 mol  (5) .91 mol

5. How many of the following statements are true about increasing the temperature of a solution?
I. Gases will be more soluble in the solution
II. The solution is doing work on the surroundings
III. The vapor pressure of the solution will go up
IV. The boiling point of the solution will go up
(1) 1  (2) 2  (3) 3  (4) 4  (5) 0

6. Which of the following compounds contains an atom with sp² hybridization?
(1) NaCl  (2) CH₂CCH₂OH  (3) HCl  (4) SO₂  (5) NF₃

7. Which of the following ions has the smallest ionic radius?
(1) Mg²⁺  (2) F⁻  (3) Na⁺  (4) Ca²⁺  (5) Ne⁻

8. The radioactive decay of Polonium-210 can be modeled as a first-order process, with a half-life of 138 days. After how much time will 70% of an initial sample of Polonium-210 have undergone decay?
(1) 138 days  (2) 276 days  (3) 240 days  (4) 396 days  (5) 68 days
9. The reaction of ozone ($\text{O}_3$) with oxygen atoms:

$$\text{O}_3(g) + \text{O}(g) \rightarrow 2\text{O}_2(g) \quad \Delta H_{\text{rxn}} = 582.7 \text{ kJ/mol}$$

Can be explained by the following mechanism:

1. $\text{NO}(g) + \text{O}_3(g) \rightarrow \text{NO}_2(g) + \text{O}_2(g) \quad \Delta H_{\text{rxn}} = -151.7 \text{ kJ/mol}$
2. $\text{NO}_2(g) + \text{O}(g) \rightarrow \text{NO}(g) + \text{O}_2(g) \quad \Delta H_{\text{rxn}} = -431 \text{ kJ/mol}$

What is the enthalpy of formation of ozone? ($\Delta H_f(\text{O}(g)) = 440 \text{ kJ/mol}$)

(1) 143 kJ/mol (2) 243 kJ/mol (3) 179 kJ/mol (4) 578 kJ/mol (5) 212 kJ/mol

10. Which of the following correctly lists compounds in order of decreasing bond length?

(1) C=O, C-O (2) H-O, H-N (3) C≡N, N≡N (4) C≡N, C=C (5) F-F, Cl-Cl

11. Consider the following chemical reaction:

$$2\text{I}^- + \text{S}_2\text{O}_8^{2-} \rightarrow \text{I}_2 + 2\text{SO}_4^{2-}$$

How many electrons are transferred in the reaction?

(1) 1 (2) 2 (3) 3 (4) 4 (5) 0

12. A chemist accidentally drops a 1 kg block of NaCl into a 10 L vat of pure ethanol (density 789 g/L). The newly-created impure solution is measured to have a boiling point of 83.7°C. What was the boiling point of the pure ethanol? ($k_{bp} = 1.22 \degree C/m$)

(1) 100°C (2) 80.3°C (3) 78.4°C (4) 30°C (5) 57.6°C

13. How many of the following compounds are polar?

CH$_2$F$_2$, BeF$_2$, XeF$_6$, HCl, H$_2$S

(1) 1 (2) 2 (3) 3 (4) 4 (5) 0

14. One 3 L vessel contains 4 atm of H$_2$ gas, and a second 2 L vessel contains 3 atm of O$_2$. The gas in these two vessels are put into a third 7 L vessel, and they react to form gaseous H$_2$O. What is the pressure of the newly-formed water vapor in this third vessel?

(1) 3.3 atm (2) 4.2 atm (3) 1.7 atm (4) 3.1 atm (5) 0.9 atm

15. How many sigma and pi bonds are there in HOCHCHCH$_2$COOH?

(1) 9 $\sigma$, 2 $\pi$ (2) 11 $\sigma$, 2 $\pi$ (3) 12 $\sigma$, 3 $\pi$ (4) 8 $\sigma$, 2 $\pi$ (5) 9 $\sigma$, 3 $\pi$

16. One way to cool down a potato that is too hot to eat is to put it in some cold water. Imagine a 200 g potato so hot, that when placed in a glass of water, some of the water vaporizes. If the glass originally had 250 mL of water at 25°C, and 25 mL of the water vaporizes, how hot was the potato to begin with? The specific heat capacity of water is 4.184 J/g°C, the heat of vaporization of water is 40.7 kJ/mol, and the heat capacity of the potato is 678 J/°C.

(1) 300°C (2) 450°C (3) 380°C (4) 400°C (5) 100°C
17. O₂ was collected over water at 780 torr and 27°C. How much O₂ was collected? (ΔH_{vap}(H₂O) = 40.7 kJ/mol)
   (1) 780 torr  (2) 750 torr  (3) 740 torr  (4) 820 torr  (5) 600 torr

18. Which of the following bonds exhibits the most covalent character?
   (1) K-Br  (2) B-F  (3) C-C  (4) Al-O  (5) C-N

19. Which of the following does not correctly pair the compound to its molecular geometry?
   (1) BH₃, trigonal planar  (2) NO₂, bent  (3) CO₂, linear  (4) XeF₂, linear  (5) IO₄⁻, seesaw

20. Which of the following statements is false?
   (1) A shorter bond length corresponds to a stronger bond  (2) Atoms which use an expanded octet always use hybridized d-orbitals  (3) If work is done on a system and its temperature also increases, then its internal energy must increase  (4) Vanadium has 5 valence electrons  (5) HCl has a theoretical van’t Hoff factor of 2

21. Consider the following atoms:
   Fe²⁺, C, Cu⁺, Ag⁺
   How many of the atoms are diamagnetic?
   (1) 1  (2) 2  (3) 3  (4) 4  (5) 0

22. 100 g of methane (CH₄) is allowed to react completely in a combustion reaction with 100 L of oxygen at STP. What is the theoretical yield of water vapor in grams?
   (1) 36.4 g  (2) 80.3 g  (3) 17.9 g  (4) 179 g  (5) 12.8 g

23. Which of the following could increase the internal energy of a gaseous system (at constant external pressure)?
   I. Decreasing the volume of the system
   II. Increasing the temperature of the system
   III. Conducting a reaction which doubles the number of particles
   (1) I only  (2) I & II  (3) II & III  (4) I, II & III  (5) none

24. One possible product of reacting hydrogen with oxygen is hydrogen peroxide (H₂O₂):
   H₂ + O₂ → H₂O₂
   What is the O-O bond energy? (Bond energies: H-H: 432 kJ/mol, O=O: 495 kJ/mol, H-O: 467 kJ/mol; Δ_{f}(H₂O₂): -153 kJ/mol)
   (1) 146 kJ/mol  (2) 232 kJ/mol  (3) 72.9 kJ/mol  (4) 129 kJ/mol  (5) 12.9 kJ/mol

25. What wavelength photon would be needed to break the O-O bond from the previous question?
   (1) 730 nm  (2) 760 nm  (3) 820 nm  (4) 660 nm  (5) 1280 nm

Good luck on your exam!