MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. The internal energy of a system is always increased by _________.
   A) adding heat to the system and having the system do work on the surroundings
   B) having the system do work on the surroundings
   C) a volume compression
   D) adding heat to the system
   E) withdrawing heat from the system

2. Which one of the following conditions would always result in an increase in the internal energy of a system?
   A) The system gains heat and does work on the surroundings.
   B) The system loses heat and has work done on it by the surroundings.
   C) The system gains heat and has work done on it by the surroundings.
   D) The system loses heat and does work on the surroundings.
   E) None of the above is correct.

3. The change in the internal energy of a system that releases 2,500 J of heat and that does 7,655 J of work on the surroundings is _________.
   A) 10,155
   B) -1.91 \times 10^7
   C) -5,155
   D) -10,155
   E) 5,155

4. Which of the following is a statement of the first law of thermodynamics?
   A) A negative $\Delta H$ corresponds to an exothermic process.
   B) $\Delta E = E_{\text{final}} - E_{\text{initial}}$
   C) $E_k = \frac{1}{2}mv^2$
   D) 1 cal = 4.184 J (exactly)
   E) Energy lost by the system must be gained by the surroundings.

5. What is expected when the reaction shown below takes place in a thermally insulated container outfitted with a movable piston at a constant atmospheric pressure of 1 atm?
   $$2 \text{C}_2\text{H}_6(g) + 7 \text{O}_2(g) \rightarrow 4 \text{CO}_2(g) + 6 \text{H}_2\text{O}(g)$$
   A) Volume will decrease and work will be done by the system.
   B) Volume will increase and work will be done by the system.
   C) Volume will decrease and work will be done on the system.
   D) Volume will decrease and work will be done on the system.

6. 10.0 g of a metal, initially at 25°C, are placed into 10.0 g of water, initially at 100°C. Which metal will have the highest final temperature? Shown after each metal is its specific heat in J/(g·°C).
   A) copper (0.385)
   B) aluminum (0.902)
   C) Gold (0.129)
   D) iron (0.450)
7) A chemical reaction that releases heat to the surroundings is said to be _________ and has a
ΔH at constant pressure.
   A) endothermic, positive
   B) endothermic, negative
   C) exothermic, negative
   D) exothermic, positive
   E) exothermic, neutral

8) A 5.00-g sample of liquid water at 25.0 °C is heated by the addition of 84.0 J of energy. The final
temperature of the water is __________ °C.
   A) 29.0
   B) 95.2
   C) -21.0
   D) 4.02
   E) 25.2

9) Which of the following is a statement of Hess's law?
   A) If a reaction is carried out in a series of steps, the ΔH for the reaction will equal the product of
      the enthalpy changes for the individual steps.
   B) The ΔH of a reaction depends on the physical states of the reactants and products.
   C) The ΔH for a process in the forward direction is equal in magnitude and opposite in sign to
      the ΔH for the process in the reverse direction.
   D) If a reaction is carried out in a series of steps, the ΔH for the reaction will equal the sum of the
      enthalpy changes for the individual steps.
   E) The ΔH for a process in the forward direction is equal to the ΔH for the process in the reverse
      direction.

10) For the reaction I₂(g) → I₂(s), ΔH° = -62.4 kJ at 25°C. Based on these data, at 25°C
   A) ΔH°sub = -62.4 kJ/mol.
      B) ΔH°sub =62.4 kJ/mol.
      C) ΔH°vap = -62.4 kJ/mol.
      D) ΔH°vap =62.4 kJ/mol.

11) Use the given standard enthalpies of formation to calculate ΔH° for the following reaction
   
   3 Fe₂O₃(s) +CO(g) → 2 Fe₃O₄(s) +CO₂(g).

<table>
<thead>
<tr>
<th>Species</th>
<th>ΔH°f, kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe₂O₃(s)</td>
<td>-824.2</td>
</tr>
<tr>
<td>Fe₃O₄(s)</td>
<td>-1118.4</td>
</tr>
<tr>
<td>CO(g)</td>
<td>-110.5</td>
</tr>
<tr>
<td>CO₂(g)</td>
<td>-393.5</td>
</tr>
</tbody>
</table>

   A) -47.2 kJ
   B) -577.2 kJ
   C) +47.2 kJ
   D) -5213.4 kJ

12) Find ΔH° for the reaction C₃H₈(g) +5 O₂(g) → 3 CO₂(g) +4 H₂O(l).
    
    ΔH° = 2046 kJ for the reaction: C₃H₈(g) +5 O₂(g) → 3 CO₂(g) +4 H₂O(g),
    the heat of vaporization of water is 44.0 kJ/mol.
   A) -1870 kJ
   B) -2222 kJ
   C) -2002 kJ
   D) -2090 kJ

13) Ethyl alcohol is produced by the fermentation of glucose, C₆H₁₂O₆.

    C₆H₁₂O₆(s) → 2 C₂H₅OH(l) +2 CO₂(g)  ΔH° = -69.1 kJ

    Given that the enthalpy of formation is -277.7 kJ/mol for C₂H₅OH(l) and -393.5 kJ/mol for CO₂(g),
    find the enthalpy of formation for C₆H₁₂O₆.
   A) -740.3 kJ/mol
   B) -602.1 kJ/mol
   C) -1273.3 kJ/mol
   D) -1411.5 kJ/mol
14) The energy released by combustion of 1 g of a substance is called the _________ of the substance.
   A) nutritional calorie content  
   B) heat capacity  
   C) fuel value  
   D) enthalpy  
   E) specific heat

15) What is a quantum of light called?
   A) a photon  
   B) the amplitude  
   C) the wavelength  
   D) the frequency

16) Arrange the following spectral regions in order of increasing wavelength: infrared, microwave, ultraviolet, visible.
   A) ultraviolet < infrared < visible < microwave  
   B) ultraviolet < visible < infrared < microwave  
   C) microwave < infrared < visible < ultraviolet  
   D) microwave < visible < infrared < ultraviolet

17) What is the frequency of a helium-neon laser light with a wavelength of 632.8 nm?
   A) $4.74 \times 10^{14}$ s$^{-1}$  
   B) $2.11 \times 10^{-15}$ s$^{-1}$  
   C) $4.74 \times 10^5$ s$^{-1}$  
   D) $1.58 \times 10^{-15}$ s$^{-1}$

18) Photochemists use electromagnetic radiation to initiate chemical reactions, often by providing the energy required to break bonds within a molecule. Lowering which of the following will result in electromagnetic radiation having more energy per photon?
   A) wavelength  
   B) amplitude  
   C) intensity  
   D) frequency

19) According to the Heisenberg uncertainty principle,
   A) the momentum of a particle cannot be measured precisely.  
   B) the position and momentum of a particle can be measured precisely, but not at the same time.  
   C) neither the position nor the momentum of a particle can be measured precisely.  
   D) the position of a particle cannot be measured precisely.

20) What are the possible values of $n$ and $m$ for an electron in a 5$d$ orbital?
   A) $n=1, 2, 3, 4, 5$ and $m=2$  
   B) $n=1, 2, 3, 4, 5$ and $m=-2, -1, 0, +1, +2$  
   C) $n=5$ and $m=-2, -1, 0, +1, +2$  
   D) $n=5$ and $m=2$

21) An electron in a $4p$ orbital can have a wave function with which of the following set of quantum numbers, $(n, l, m, s)$?
   A) $(4, 1, -1, -1/2)$  
   B) $(5, 4, 4, 1/2)$  
   C) $(4, 0, 0, 1/2)$  
   D) $(5, 4, 1, -1/2)$

22) Which of the following represent electron configurations that are allowed but do not represent ground-state configurations?
   (A) [Ne]3$s^2$3$p^5$  
   (B) [Kr]4$d^{12}$5$s^2$5$p^3$  
   (C) [Ar]3$d^{10}$4$s^2$4$p^2$  
   A) only (A)  
   B) only (B)  
   C) (A) and (B)  
   D) (B) and (C)
23) What is the ground-state electron configuration of Molybdenum?  
A) [Kr] 5s² 4d⁴  
B) [Kr] 5s¹ 4d⁵  
C) [Kr] 5s⁰ 4d⁰ 5p⁶  
D) [Kr] 5s⁰ 4d⁶  

24) How many unpaired electrons are in an atom of Co in its ground state?  
A) 7  
B) 3  
C) 1  
D) 2  

25) A neutral sulfur atom has how many valence electrons?  
A) 4  
B) 2  
C) 6  
D) 16  

26) Which electron configuration represents a violation of Hund’s rule for an atom in its ground state?  
A)  
B)  
C)  
D)  
E)  

27) Electromagnetic radiation with a wavelength of 525 nm appears as green light to the human eye. What is the energy of one photon of this light? (h=6.627 ×10⁻³⁴ J·s)  
A) 2.64 ×10¹⁸  
B) 1.04 ×10⁻³¹  
C) 3.79 ×10⁻²⁸  
D) 1.04 ×10⁻²²  
E) 3.79 ×10⁻¹⁹