**NCS Science Olympiad Invitational (Division C)**

***Thermodynamics Exam*** Team Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Multiple Choice (2 points each)**

1. Which of the following are NOT considered intensive properties?
   1. Mass
   2. Density
   3. Weight
   4. Length
2. The Second Law of Thermodynamics states that the changes in the entropy in the universe as an isolated system can
   1. decrease over time
   2. remain constant over time
   3. never be negative
3. John is cooking and decides to stir the spaghetti he is cooking with his fork, rather than have to wash a wooden spoon. He leaves the fork in the pan and prepares the rest of his meal. The stove provides 1000 J of energy to the fork in the time he leaves it unattended. What would be the temperature increase in the fork, assuming half the energy provided will be lost to the surroundings, the initial temperature of the fork was 20°C, and the mass of the fork is 50g which is made of a material with a specific heat capacity of 460 J/(kg\*K)?
   1. 22 oC
   2. 42 oC
   3. 63 oC
   4. 63.04 oC
4. A balloon filled with gas expands under a constant pressure of 2.0×105 Pa from a volume of 5.0 L to 10 L. How much work was done on the system?
   1. 1 kJ
   2. 1000 kJ
   3. -1 kJ
   4. -1000 kJ
5. The maximum possible efficiency of a heat engine is determined by which of the following:
   1. The maximum and minimum pressure
   2. The amount of heat that flows
   3. The compression ratio
   4. The maximum and minimum temperature
6. If 0.100 moles of hydrogen gas occupies an inflexible container with a capacity of 775 mL and the temperature is raised from 25.0 oC to 60.0 oC, what is the change in pressure of the contained gas, assuming ideal behavior? R = 0.082057 (L\*atm)/(mol\*K)
   1. 2.45 atm
   2. 0.371 atm
   3. 3.13 atm
   4. 2.82 atm
7. If 1.6g of CH4 reacts with oxygen gas to form water and carbon dioxide what best describes the change in entropy for the universe?
   1. Entropy of the system increases
   2. Entropy of the system stays the same
   3. Entropy of the system decreases
   4. There is not enough information to determine change in Entropy
8. If a swimming pool with a depth of 5 ft and wading pool with a depth of 2 ft, both full of water at the same temperature, were subjected to the same input of heat energy, which would best describe the change?
   1. The swimming pool would rise in temperature more quickly than the wading pool.
   2. The wading pool would rise in temperature more quickly than the swimming pool.
   3. The temperature of the pools would rise at the same rate.
9. It take 487.5 J to heat 25 g of copper from 25 oC to 75 oC. What is the specific heat of copper?
   1. 390 J/(g\*oC)
   2. 0.39 J/(g\*K)
   3. 0.39 J/(g\*oC)
   4. 390 J/(g\*K)
10. An ideal gas undergoes a cyclic process presented by the P - V diagram. Which of the following points has the highest temperature?



* 1. A
  2. B
  3. C
  4. D
  5. E

1. Which of the following temperature scales doesn’t have negative numbers?
   1. Celsius
   2. Kelvin
   3. Reaumur
   4. Fahrenheit



1. The state of an ideal gas is changed in a closed path 1🡪2🡪3🡪4🡪1. Which of the following is true about work done on the gas?

Work 1🡪2 Work 2🡪3 Work 3🡪4 Work 4🡪1

1. W > 0 W = 0 W < 0 W = 0
2. W < 0 W = 0 W = 0 W > 0
3. W < 0 W = 0 W > 0 W = 0
4. W = 0 W > 0 W = 0 W < 0
5. W = 0 W < 0 W = 0 W > 0
6. The process of heat transfer by the movement of mass from one place to another is called:
   1. Convection
   2. Conduction
   3. Induction
   4. None of the above
7. An ideal heat engine operates between two temperatures: 600 K and 900 K. What is the efficiency of the engine?
   1. 10%
   2. 33%
   3. 50%
   4. 80%
   5. 100%
8. Internal energy of an ideal gas depends on:
   * 1. The volume of the ideal gas
     2. The pressure of the ideal gas
     3. The absolute temperature of the ideal gas
9. I
10. II
11. III
12. I and II
13. I, II and III
14. The state of an ideal gas was changed three times at three different temperatures. The diagram represents three different isothermal curves. Which of the following is true about the temperature of the gas?



1. T1 > T2 > T3
2. T1 > T2 < T3
3. T1 < T2 < T3
4. T1 > T2 = T3
5. T1 = T2 > T3
6. A container filled with a sample of an ideal gas at the pressure of 1.5 atm. The gas is compressed isothermally to one-fourth of its original volume. What is the new pressure of the gas?
   1. 2 atm
   2. 3 atm
   3. 4 atm
   4. 5 atm
   5. 6 atm
7. The area enclosed within a pV curve for a heat engine represents
   1. The work done by the system during one complete cycle.
   2. The work done on the system during one complete cycle.
   3. The thermal energy change of the system during one complete cycle.
   4. The heat transferred out of the system during one complete cycle.
8. Which of the two temperature changes are equivalent?
   1. +1 K = +1 oF
   2. +1 oF = +1 oC
   3. +1 Re = +1 oF
   4. +1 K = +1 oC
9. The temperature gradient in a rod of 0.5m length is 80oC/m. If the temperature of the hotter end of the rod is 30oC, then the temperature of the cooler end is
   1. 313K
   2. 263K
   3. 283K
   4. 3030K

**True/False (1 point each)**

1. The average molecular kinetic energy of a gas depends on temperature.
2. As a spring is compressed adiabatically, its internal energy increases.
3. Snow is a better insulator than ice.
4. The First Law of Thermodynamics specifies the direction of flow of heat and mass.
5. The Zeroth Law of Thermodynamics states that two systems are in thermal equilibrium if they could transfer heat between each other, but do not.

**Short Answer (3 points each)**

1. The rate of heat transfer to the surroundings from a person at rest is about 400kJ/h. Suppose the ventilation systems fails in an auditorium containing 1000 people. How much does the internal energy of the air in the auditorium increase during the first 30 minutes after the ventilation system fails?
2. The gas space above the water in a closed tank contains nitrogen at 25 oC, 100kPa. The tank has a total volume at 4m3 and contains 500kg of water at 25 oC. An Additional 500kg of water is now slowly forced into the tank. Assuming the temperature remains constant, calculate the final pressure of the nitrogen in the tank.
3. You are now operating a Carnot engine at 40.0% efficiency, which exhausts heat into a heat sink at 298 K. If you want to increase the efficiency of the engine to 65.0%, to what temperature would you have to raise the heat reservoir?
4. When methanol, CH3OH, is burned in the presence of oxygen gas, O2, a large amount of heat energy is released, as shown in the combustion reaction below.

2CH3OH(g) + 3O2(g) --> CO2(g) + 2H2O(l)

*Given:* ΔHc methanol = -715 kJ/mol

Atomic Mass C= 12.01 g/mol

Atomic Mass H= 1.01 g/mo

Atomic Mass O= 16.01 g/mol

Based on the balanced thermochemical reaction above, how much heat is produced when 23.9 g of methanol react with 37.1 g of oxygen?

1. 300 grams [of ethanol](https://www.thoughtco.com/what-is-ethanol-1203782) at 10 °C is heated with 14640 Joules of energy. What is the final temperature of the ethanol?

Given: specific heat of ethanol is 2.44 J/g·°C.