Question 1 (40 points). Select the **most correct** answer and circle it in the following multiple choice questions (MCQ). **More than one answer may be correct**, make your choices carefully and wisely.

1. In thermodynamics, a fixed quantity of mass selected for the purpose of study is called a:

a) System | [redacted] Closed system | **c)** Open system | **d)** Control volume

2. A specific property is also:

a) An extensive property | **b)** The product of two intensive properties | **c)** An amount of mass dependent property | [redacted] An intensive property

3. In order for a system to be in thermal equilibrium, which of the following properties must be the same throughout the system?

a) Mass | **b)** Pressure | [redacted] Temperature | **d)** Volume

4. A cycle consists of a series of processes that:

[redacted] Eventually return to the first state of the first process | **b)** are continually repeated | **c)** are always in equilibrium or quasi-equilibrium | **d)** none of these

5. How many independent properties are required to completely specify the state of a simple compressible system?

a) 0 | **b)** 1 | [redacted] 2 | **d)** 3

6. A 0.5 m^3 container is filled with a fluid whose specific volume is 0.001 m^3/kg. At standard gravitational acceleration, the contents of this container weigh:

a) 2010 N | **b)** 3220 N | [redacted] 4900 N | **d)** 7830 N

7. Which temperature below is equivalent to 125°F?

[redacted] 52°C | **b)** 125°C | **c)** 602°R | **d)** 315 K

8. On a day when the barometer reads 755 mm Hg, a tire pressure gage reads 204 kPa. The absolute pressure in the tire is:

a) 100 kPa | **b)** 204 kPa | **c)** 1.54 m Hg | [redacted] 2.29 m Hg

9. The boundaries of a system can be

a) Real or imaginary | **b)** May be at rest or in motion | **c)** may change size or shape | [redacted] All of these

10. The modes of contact between the system and its surroundings are

a) Mechanical, thermal, and physical. | [redacted] Mechanical, thermal, and chemical. | **c)** Mechanical and thermal. | **d)** None of these

11. An extrinsic property is

a) State function | **b)** path function | **c)** Dependent on the nature of the constituents of the system | [redacted] not dependent on the nature of the constituents of the system

12. The equilibrium state is affected by

a) Nature of the system | **b)** Container | **c)** Surroundings | [redacted] All of these

13. Equilibrium states can be classified as

a) Stable and unstable | **b)** Stable, metastable, and unstable | [redacted] Stable, neutrally stable, and unstable | **d)** Stable, neutrally stable and metastable

14. To measure very high temperatures, we use

a) Thermometers | **b)** Cryometers | [redacted] Pyrometers | **d)** Thermocouples

15. The different kinds of work that occur at the system-surroundings boundaries are

a) Shaft | [redacted] Deforming system boundaries, shaft and fields. | **c)** Accompany mass flow only | **d)** All of these

16. Heat and work are

a) Interactions between the system and its surroundings | **b)** Occur in the bulk | **c)** Energy in transit | [redacted] A and C

17. Adiabatic processes can occur in

a) A unique way | [redacted] Two ways | **c)** Three ways | **d)** None of these

18. All types of energy can be reduced to

a) Kinetic energy | **b)** Potential energy | **c)** Internal energy | [redacted] Kinetic and potential energies

19. The internal energy is related to

[redacted] Microscopic energy | **b)** Macroscopic energy | **c)** Both macro and microscopic energies | **d)** None of these

20. The first law of thermodynamics as derived is subject to which of the following assumptions

a) No nuclear reactions | **b)** No electro-magnetic fields | **c)** No gravity fields | [redacted] A and B

Question 2 (30 points). An average car consumes about 5 L of gasoline a day, and the capacity of the fuel tank of the car is about 50 L. Therefore, a car needs to be refueled once every 10 days. Also, the density of gasoline ranges from 0.72 to 0.78 kg/L, and its lower heating value is about 44,000 kJ/kg. Suppose all the problems associated with the radioactivity and waste disposal of nuclear fuels are resolved, and a car is to be powered by U-235. The complete fission of 1 kg of U-235 releases 6.73×10^{10} kJ of heat. If a new car comes equipped with 0.1 kg of the nuclear fuel U-235, determine if this car will ever need refueling under average driving conditions.

Strategy: know the mass of gasoline and obtain the total energy supplied to the car per day. From this obtain the fission energy of the 0.1 kg of U-235. Divide the fission energy by that of the daily requirements to obtain the time before the mass of uranium is consumed.

- Obtain mass of gasoline

$$m_{\text{gasoline}} = (\rho V)_{\text{gasoline}} = (0.75\frac{kg}{L})\bullet(5\frac{L}{day}) = 3.75\frac{kg}{day}$$

- We know the heating value of gasoline from which we can determine the energy supplied to the car per day.

$$E_{\text{day}} = m_{\text{gasoline}}(\text{Heating value}) = 3.75\frac{kg}{day}\bullet(44000\frac{kJ}{kg}) = 165000\frac{kJ}{day}$$

- Obtain how much energy is released due to the complete fission of the uranium mass

$$E_{\text{Total}} = m_{\text{U-235}}(\text{Fission energy}) = (0.1kg)\bullet(6.73\times10^{10}\frac{kJ}{kg}) = 6.73\times10^{9}kJ$$

- Find the number of days from the fission energy and the daily requirements of the car

$$Days = \frac{\text{Energy content of the fuel}}{\text{Daily energy use}} = \frac{6.73\times10^{9}kJ}{165000kJ/day} = 40790days$$

- These days are equivalent to about 112 years. Considering that no car will last more than 100 years, and no driver will live on average more than 100 years, this car will never need refueling.

Question 3 (30 points). A cyclic process is carried in five (5) steps on a closed system composed of one mole of a certain gas. The following table has some missing values. Fill in the missing values.

Use the energy balance for a closed system for the process and for the individual steps

$$\Delta U = Q + W$$

Now follow the following sequence of steps to obtain the missing values

1. We know that for the overall process the internal energy change is zero since it is a state function ΔU_{123451}=0 J.
2. Now from knowledge of $\Delta U_{123451} = 0$ J, we can find the work term for the process from the energy balance equation $W_{123451} = \Delta U_{123451} - Q_{123451} = -2000$ J.
3. For step 12 we can obtain the internal energy change associated with this step as $\Delta U_{12}=Q_{12}+W_{12}$. From which $\Delta U_{12} = 3000$ J.
4. Looking at the first column (the process internal energy change is the sum of the changes of the individual steps). This enables us to find the internal energy change of step 51. From which: $\Delta U_{51} = -4000$ J.
5. Again at step 51, we can obtain $W_{51} = \Delta U_{51} - Q_{51} = -6000$ J.
6. The heat of step 45 is given as: $Q_{45} = \Delta U_{45} - W_{45} = -2000$ J.
7. Find the work in step 34 as: $W_{34} = \Delta U_{34} - Q_{34} = 2000$ J.
8. Find the heat in step 23 from the fact that the sum of the steps heat transfer is equal to the process heat transferred. Q_{23}= 2500 J.
9. From the energy balance in step 23 we can obtain the work. W_{23}= -1000 J.
10. Check the solution is correct by summing up all the work terms and see if they are equal to the overall process work. (Checked)
11. The following table is now the solution to the cyclic process in the problem.

	ΔU (J)	**Q (J)**	**W(J)**
12	**3000**	**1000**	**2000**
23	**1500**	**2500**	**-1000**
34	**500**	**-1500**	**2000**
45	**-1000**	**-2000**	**1000**
51	**-4000**	**2000**	**-6000**
123451	**0**	**2000**	**-2000**