1 Based on the zeroth law of thermodynamics, one could assign a quantity (temperature) to systems, so that the warmer the system, the larger the temperature. Which of the following is correct?

a On the Celsius scale of temperature, no negative temperature exists.

b On the Celsius scale of temperature, no positive temperature exists.

c Only on the Celsius scale of temperature, the temperature of the boiling water is larger than the temperature of freezing water.

d On all temperature scales, the temperature of the boiling water is larger than the temperature of freezing water.

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2 The first law of thermodynamics is essentially a statement of conservation of energy. Which of the following is **forbidden** by the first law of thermodynamics.

a Transforming heat into mechanical work.

b Transforming mechanical work into heat.

c A system going on a cycle, so that its final and initial states being the same.

d A system gaining net energy when going on a cycle.

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3 The engine of a car goes on a cycle, in which it burns fuel and produces mechanical work. Which of the following could be **impossible** (on a cycle)?

a Transforming the heat gained from a single source completely into mechanical work.

b Transforming the mechanical work gained completely into heat.

c Transforming the heat gained from a single source partially into mechanical work.

d Transforming the mechanical work gained partially into heat.

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4 Le Chatelier's principle states that when some change is applied to a system, the system moves in such a direction that the effect of the change is partially canceled. The density of liquid water is larger than the density of solid water (ice). Increasing the pressure on a mixture of water and ice, in constant temperature,

a causes some water to freeze.

b causes some ice to melt.

c does not change the amount of water and ice.

d in low temperatures causes some water to freeze, and in high temperatures causes some ice to melt.

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5 Hydrogen and oxygen react with each other to produce water. The reaction is reversible. In the reaction in the gas phase, two molecules of hydrogen react with one molecule of oxygen to produce two molecules of water. At constant volume and temperature, the pressure of a gas mixture is proportional to the number of molecules. Based on these, and le Chatelier's principle, what does happen when a mixture of hydrogen, oxygen, and water vapor are kept at constant temperature and no particles comes in or goes out (a sealed container), and the pressure is increased?

a The reaction proceeds in the direction of making water.

b The reaction proceeds in the direction of making oxygen and hydrogen.

c The amounts of water, oxygen, and hydrogen remain fixed.

d The amounts of water, oxygen, and hydrogen all decrease.

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6 When the force applied to a particle is central, the angular momentum of the particle is conserved. The angular momentum is a vector which is perpendicular to both the position vector and the velocity vector. When the force is central,

a the particle moves on a fixed line which is parallel to the angular momentum.

b the particle moves on a fixed line which is perpendicular to the angular momentum.

c the particle moves on a fixed plane which is parallel to the angular momentum.

d the particle moves on a fixed plane which is perpendicular to the angular momentum.

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7 Consider two point particles which rotate around their center of mass at constant angular velocities. The system of the sun and the earth is roughly such a thing. There are 5 points so that if a test particle (a particle of a negligible mass compared to those, say a spaceship) is put at one of these points with suitable initial velocity, it would remain stationary relative to those two point particles. These 5 points are called the Lagrange points. Of these, 3 lie in the line connecting the two point particles. The convention for the enumeration of the Lagrange points is the following. The first 3 Lagrange points are those which lie on the line connecting the two point particles. The first Lagrange point is between the two point particles. The particle of the lower mass is between the second Lagrange point and the particle of the higher mass. The particle of the higher mass is between the third Lagrange point and the particle of the lower mass. The fourth Lagrange point makes an equilateral triangle with the particles, and the same is true for the fifth Lagrange point. All of the Lagrange points, as well as the two particles, lie in the same plane. If the mass of the particle of the lower mass is much less that that of the particle of the higher mass (as the mass of the earth is much lower than the mass of the sun), then the distances of the first 3 Lagrange points from the two particles have a simple form. If the ratio of the lower mass to the higher mass is α, and the distance of the two particles is R, then the distance of the first and second Lagrange points from the particle of the lower mass is $R\,(\alpha/3)^{1/3}$, and the distance of the third Lagrange point from the particle of the higher mass is the same as R.

Consider the Lagrange points of the system of the earth and the sun. The distance of the earth from the sun is 150 million km. The mass of the earth is 6×10^{24} kg, and the mass of the sun is 2×10^{30} kg. How many million km is the distance of the first Lagrange point from the earth?

a 1.5 **b** 150 **c** 260 **d** 300

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8 In the previous problem, how many million km is the distance of the second Lagrange point from the earth?

a 1.5 **b** 150 **c** 260 **d** 300

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9 In the previous problem, how many million km is the distance of the third Lagrange point from the earth?

a 1.5 **b** 150 **c** 260 **d** 300

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10 In the previous problem, how many million km is the distance of the fourth Lagrange point from the fifth Lagrange point?

a 1.5 **b** 150 **c** 260 **d** 300

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11 The kilogram force (kgf) is a unit of force (not mass). It is equal to the weight of a body of mass 1 kg, near earth, where the acceleration of gravity is 9.8 m s^{-2}. The pressure of the atmosphere (at the sea level) is 10^5 Pa. (Pa is Pascal, the unit of pressure in SI, which is equal to 1 kg m^{-1} s^{-2}). How many kgf cm^{-2} is the pressure of the atmosphere at the sea level?

a 0.001 **b** 1 **c** 1000 **d** 10^6

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12 The BTU is a unit of energy (heat). It is equal to the amount of heat needed to increase the temperature of 1 lb of water by 1°F (one degree Fahrenheit). 1 lb is 0.4536 kg. The relation of the temperature in Fahrenheit scale with the temperature in the Celsius scale is at most linear. The freezing point of water is 0°C and 32°F, while the temperature of the boiling water is 100°C and 212°F. The calorie is the amount of heat needed to increase the temperature of 1 g of water by 1°C (one degree Celsius). How many calories is one BTU?

a 252 **b** 331 **c** 454 **d** 561

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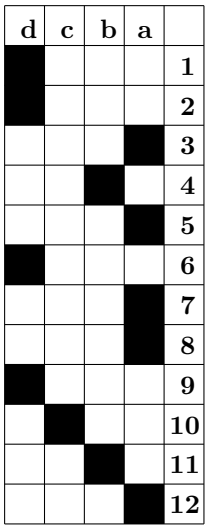
13 Good luck!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