October 2022

Science Olympiad at the University of Texas at Austin

Solar Power B

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Directions:

1. In order to earn full credit, correct significant figures and units must be included in the answer, unless stated otherwise.
2. Teams will have 50 minutes to complete the exam.

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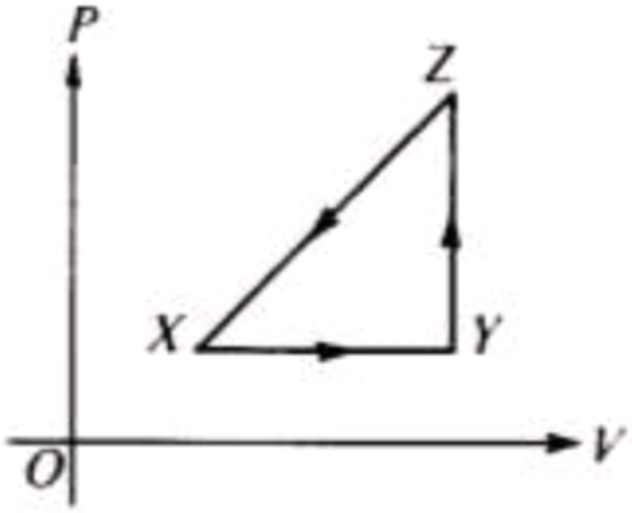
1. (1.00 pts) An aluminum plate has a circular hole in the middle. What happens to the size of the hole as the plate is heated up?

- A) Increases
- B) Decreases
- C) Stays the same
- D) Increases the top half of the hole
- E) More information is required

2. (1.00 pts)
Use the figure below to answer the next 2 questions, where a thermodynamic system begins at the initial state X and travels along the path shown in the P-V diagram.



From X→Y, ΔU> 0 and

- A) Q < 0 and W = 0
- B) Q < 0 and W > 0
- C) Q > 0 and W < 0
- D) Q > 0 and W = 0
- E) Q > 0 and W > 0

3. (1.00 pts) From Y→Z, ΔU> 0 and

A) $W < 0$ & $Q = 0$

B) $W = 0$ & $Q < 0$

C) $W = 0$ & $Q > 0$

D) $W > 0$ & $Q = 0$

E) $W > 0$ & $Q > 0$

4. (1.00 pts)
The average kinetic energy of molecules in an ideal gas at temperature T is E. What is the average kinetic energy of molecules in an ideal gas if the temperature is doubled?

A) $2/\sqrt{E}$

B) E

C) $\sqrt{2E}$

D) 2E

E) 4E

5. (1.00 pts) A container filled with an ideal gas has a temperature T. What happens to the pressure of the container when the temperature doubles?

A) Doubles

B) Quadruples

C) Triples

D) Decreased to one half

E) Decreased to one fourth

6. (1.00 pts) Which type of heat transfer describes the internal transfer of heat through vibrations of atoms and molecules?

A) Convection

B) Radiation

C) Conduction

D) Advection

E) Diffusion

7. (1.00 pts)
Two scientists perform an experiment to identify the boiling point of an unknown substance. The first scientist measures 120°C and the second scientist measures 250°F. Which measurement is higher and by how much?

A) 250°F is the higher temperature by 2°C

B) 250°F is the higher temperature by 2°F

C) 120°C is the higher temperature by 2°C

D) 120°C is the higher temperature by 2°F

E) They are both the same temperature.

8. (3.00 pts) Choose all of the following elements that can be used in this process to create N-type semiconductors.

(Mark **ALL** correct answers)

A) Arsenic

B) Antimony

C) Boron

D) Galium

E) Bismuth

9. (1.00 pts) What is the name of the process that adds impurities to pure semiconductors in order to alter its electrical properties?

10. (1.00 pts) This is the main source of energy for humans:

- A) Natural gas
- B) Oil
- C) Waves in the ocean
- D) The Sun
- E) Nuclear power plants

11. (1.00 pts) Energy is created when wind blows into a turbine and turns the

- A) blades that connect to a gearbox.
- B) generators that are placed underground.
- C) drains that irrigate wetlands.
- D) towers that maintain farms

12. (3.00 pts) Which of the following are greenhouse gases? Choose multiple answers.

(Mark **ALL** correct answers)

- A) Carbon Monoxide
- B) Methane
- C) Helium
- D) Sulfur Hexafluoride
- E) Nitrogen
- F) Nitrous Oxide

13. (1.00 pts)
Fill in the blank with the term or phrase best paired with the following definition: the highest rate at which a potentially renewable resource can be used indefinitely without reducing its available supply.

14. (1.00 pts) Geothermal energy is made from the production of high pressure and the breakdown of underground _____ elements.

15. (1.00 pts) Greenhouses use _____ solar heating to collect the sun's energy.

- A) active
- B) passive

16. (1.00 pts) What substance allows solar power plants to provide 24 hours of power, even when the sun is not shining?

17. (2.00 pts) The Investment Tax Credit (ITC) offers a financial incentive for the use of _____ power by allowing a federal tax deduction of ___% of the cost of installation.

18. (4.00 pts) Wind and solar power are both examples of _____ resources (hint: be more specific than renewable)

19. (1.00 pts) _____ force is ultimately responsible for the energy obtained by tides.

20. (1.00 pts) A tidal range of at least how many feet is required to economically produce tidal energy?

- A) 5
- B) 8
- C) 10
- D) 12
- E) 17

21. (4.00 pts)
Contrary to what the common phrase "Reuse, Reduce, Recycle" suggests, there are actually 5 "Rs" of waste management. Fill in the missing terms in order of the 5 Rs hierarchy: _____, Reduce, Reuse, _____, Recycle

22. (2.00 pts)
The combustion of fossil fuels during electricity production results in large amounts of wasted heat. As a result, power plants can become more efficient by installing a CHP unit that utilizes this heat for other functions. This practice of utilizing the otherwise wasted heat created in power plants is called:

(Mark **ALL** correct answers)

- [ ] A) Distributed generation
- [ ] B) Recycled energy
- [ ] C) Thermal-electrical conservation
- [ ] D) Cogeneration
- [ ] E) Coefficiency

23. (1.00 pts) Because hydropower does not burn material to create energy, this process prevents the pollution of the atmosphere

True False

24. (1.00 pts) When an object has a temperature of 0°C, it no longer has thermal energy.

True False

25. (1.00 pts) Solar panels provide a method for passive heating.

True False

26. (1.00 pts) Specific heat describes the amount of energy needed to reduce the temperature of a substance of 1 kg by 1 degree.

True False

27. (1.00 pts) Like many other heating systems, GHP systems generate heat rather than transferring it.

○ True ○ False

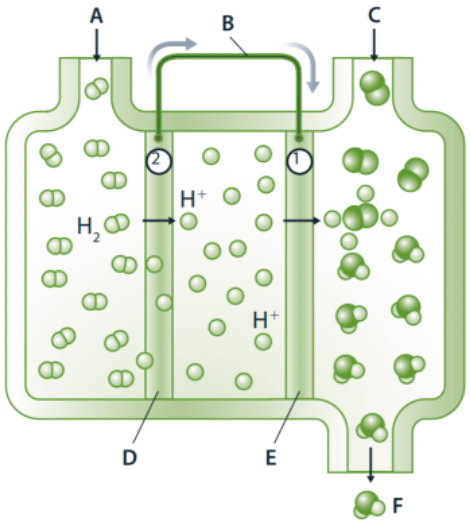
28. (1.00 pts) Once built, the energy created by wind turbines results in no greenhouse gas emissions.

○ True ○ False

29. (1.00 pts) Hydrolysis is the process of the breakdown of water into gaseous hydrogen and oxygen.

○ True ○ False

30. (1.00 pts) Check whether the events in the fuel cell for each corresponding letter are true or false.



Part A describes hydrogen entering the side of the electrode with the negative terminal

○ True ○ False

31. (1.00 pts) Part B describes oxygen entering the cell on the side with the positive electrode.

○ True ○ False

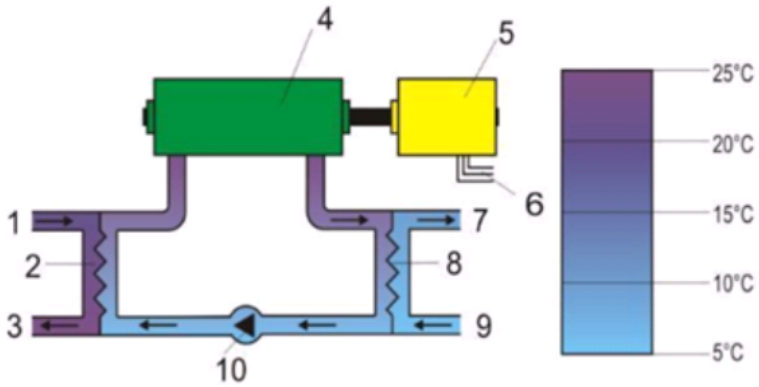
32. (1.00 pts) Part D is the negative electrode, and part E is the positive electrode.

○ True ○ False

33. (1.00 pts) An open system gains and loses energy due to its surroundings.

○ True ○ False

34. (1.00 pts) Label the parts of the closed cycle system. Given is a word bank with all the terms needed to fill in the diagram.



Word Bank: circulation pump, condenser, evaporator, waste water, surface water, turbine, line to grid, waste water, deep water, generator

What is part 1?

35. (1.00 pts) What is part 2?

36. (1.00 pts) What is part 3?

37. (1.00 pts) What is part 4?

38. (1.00 pts) What is part 5?

39. (1.00 pts) What is part 6?

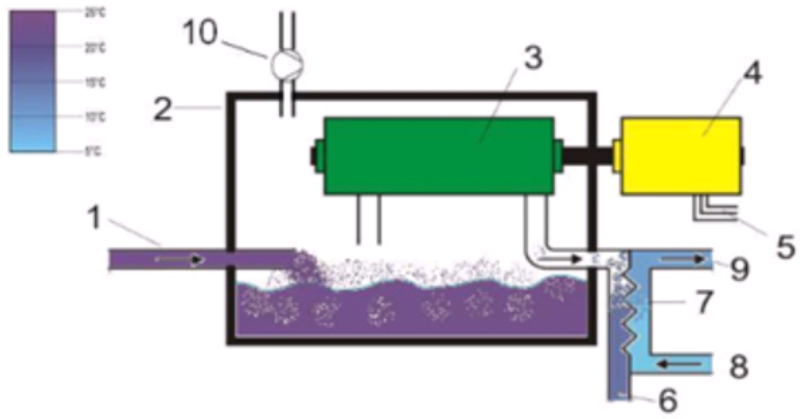
40. (1.00 pts) What is part 7?

41. (1.00 pts) What is part 8?

42. (1.00 pts) What is part 9?

43. (1.00 pts) What is part 10?

44. (1.00 pts) Label the parts for the open cycle system. Given is a word bank with the correct terms for each number.



Word Bank: generator, surface water, vacuum chamber, desalinated water, vacuum pump, waste water, deep water, condenser, line to grid, turbine

What is part 1?

45. (1.00 pts) What is part 2?

46. (1.00 pts) What is part 3?

47. (1.00 pts) What is part 4?

48. (1.00 pts) What is part 5?

49. (1.00 pts) What is part 6?

50. (1.00 pts) What is part 7?

51. (1.00 pts) What is part 8?

52. (1.00 pts) What is part 9?

53. (1.00 pts) What is part 10?

54. (1.00 pts) Which law states that energy cannot be created or destroyed?

- A) First law of thermodynamics
- B) Second law of thermodynamics
- C) Third law of thermodynamics
- D) Fourth law of thermodynamics

55. (1.00 pts) What is the most abundant fossil fuel on Earth?

- A) Coal
- B) Natural gas
- C) Crude
- D) Wood
- E) Petroleum

56. (1.00 pts) A transducer is a device that converts _____ energy to _____ energy.

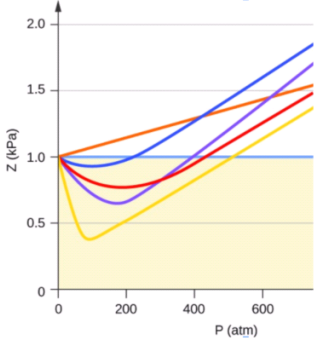
57. (3.00 pts)
A copper pipe with a diameter of 20 mm has a convective heat transfer coefficient of $h = 6W/m^2K$. Find the convection per meter of the pipe when the external temperature is 80°C and the surroundings are at 20°C. Round to the nearest tenth and give your answer in terms of W/m. Do not write the units in the answer space.

58. (1.00 pts) Convert 50°F to Celsius. Round to the nearest whole number and give your answer as an integer without units.

59. (1.00 pts) Which of the following relationships does not follow from the ideal gas law, where V = volume?

- A) V ∝ pressure
- B) V ∝ temperature
- C) V ∝ number of moles
- D) V ∝ mass

60. (1.00 pts)
Compressibility is a key determinant of how much work can be done on or by a gas, and can be defined as Z = PV/RT where V is the molar volume. Which of the following lines identifies an ideal gas?



A) Dark blue
B) Light blue
C) Orange
D) Yellow

61. (1.00 pts)
An ideal gas in a closed container initially has volume V, pressure P, and Kelvin temperature T. If the temperature is changed to 3T, which of the following pairs of pressure and volume values is possible?

A) 3P and V
B) P and V
C) P and V/3
D) P/3 and V
E) 3P and 3V

62. (1.00 pts) Which of the following is always a characteristic adiabatic process?

A) The temperature does not change
B) The internal energy does not change
C) No work is done on or by the system
D) The pressure does not change
E) No heat flows into or out of the system

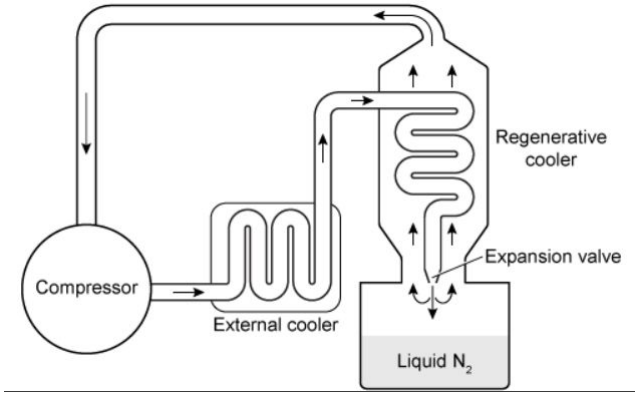
63. (1.00 pts) According to the kinetic theory of gases, when the absolute temperature of an ideal gas doubles, the average kinetic energy of the molecules of the gas

A) quadruples
B) doubles
C) stays the same
D) is cut in half
E) is quartered

64. (1.00 pts) The theoretical Carnot efficiency of a heat engine operating between 600 °C and 100 °C is

A) 16.7%
B) 20.0%
C) 42.7%
D) 57.3%
E) 83.3%

65. (1.00 pts) Examine the fluid flow schematic below. By what process is the flowing gas transferring heat to the external cooler?

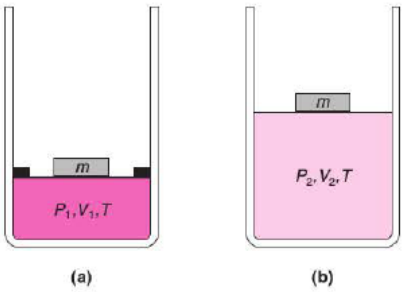


A) Convection
B) Conduction
C) Radiation
D) Successive rounds of expansive cooling and thermal contraction

66. (1.00 pts)
The work done during a gas expansion or contraction is related to pressure and change in volume. More specifically, “pressure” refers to pressure of the _____ while change in volume refers to change in volume of the _____.

A) System, system
B) System, surroundings
C) Surroundings, system
D) Surroundings, surroundings

67. (1.00 pts)
Imagine that a gas is weighed down by a piston with weight on it, as below. Which of the following scenarios would produce the maximum magnitude of work done BY the gas? Assume all are realistically possible. Hint: draw out each process on a PV diagram if you need to.



A) Removing all of the weight all at once to let the gas fully expand
B) Removing an infinitesimally small amount of weight little by little until all of the weight is removed and the gas has fully expanded
C) None of the above; both would produce the same magnitude of work

68. (1.00 pts)
There are two kinds of commonly used heat capacities in gaseous thermodynamic problems. C_p refers to the heat capacity at constant pressure. C_v refers to the heat capacity at constant volume. For a given amount of a gas which is being heated, which is higher, its C_v or C_p?

A) Cv, because gas requires more energy to become hotter when constrained by a constant volume
B) Cp, because some heat would be lost to expansion work
C) Cp, because some heat would be lost to contraction work
D) Cv, because a constant volume would lead to more gas particles colliding as it expands

69. (1.00 pts) Doping is the process that adds impurities to pure semiconductors in order to alter its electrical properties.

○ True ○ False