Keep the Heat
JC Booth Invitational, 1/21/12

Score: _____

Team Name: _____ Team# _____

Team Members: _____

BE SURE TO USE THE CORRECT NUMBER OF SIGNIFICANT FIGURES AND SI UNITS.

1 What absorbs more radiant energy? (circle one)
Shiny objects
Dull objects

2 Who first used the term “entropy”? _____

3 Convert 70°C to Kelvin. _____

4 A mathmatical approach to the First Law of Thermodynamics is: (circle one)
U = P + Q
Q = W + E
U = Q - W

5 Which of the reversible processes listed below are used to form a Carnot cycle? (circle one)
Isometric, isobaric
Isometric, adiabatic
Isobaric, adiabatic
Isothermal, adiabatic

6 Which will be cooler if left in the sun? (circle one)
A shiny object
A dull object

7 What type of heat transfer involves electromagnetic waves in the infrared region?_____

8 A state change from liquid to solid is called _____

9 In the formula $Q = \Delta U + W$, the Q stands for _____

10 Give three methods of heat transfer._____

11 Water freezes at _____ degrees on the Fahrenheit scale.

12 The Second Law of Thermodynamics would back up this statement: Disorganized energy can be changed to orderly usable energy only by doing work. True or False (circle one)

13 Which will be hotter if left in the sun? (circle one)
A light colored car
A dark colored car

14 The Third Law of Thermodynamics refers to a state known as “absolute zero”. This is the bottom of which temperature scale?_____

15 In thermodynamics there are three types of systems. An isolated system does not allow any heat and matter transfer between the system and its surroundings. An open system allows both heat and matter transfer. What is the name given to the system that allows heat transfer but prevents matter transfer?_____

16 Pressure, volume, internal energy, entropy, and Gibb’s free energy are all state functions because their values are dependent only on the initial and final state of the system, regardless of the route taken. Non-state functions are so-called because their values depend on the route taken. What are two examples of non-state functions? (circle one)
Enthalpy and heat
Work and heat
Work and temperature
Enthalpy and temperature

17 The Second Law of Thermodynamics would back up this statement: In a piston, as heat is added, all of the moleculeswill move in the same direction, pushing the piston up. True or False (circle one)

18 Consider three systems, X, Y, and Z. If X and Z are in thermal equilibrium, and Y and Z are in thermal equilibrium, then X and Y will also be in thermal equilibrium. This is known as the Zeroth Law of Thermodynamics. True or False (Circle one)

19 What temperature scale assigns 0 degrees as the freezing point of water, and 100 degrees as the boiling point of water? _____

20 The Third Law of Thermodynamics says that as the temperature of a substance approaches absolute zero, the entropy approaches zero. True or False (circle one)

21 A form of heat transfer that occurs by currents in a fluid (gas or liquid) is called _____

22 If the internal energy of a system increases, then the _____ of the system will increase.

23 In the formula $Q = \Delta U + W$, the W stands for _____

24 Two strips of different metals, permanently bonded together, will curve when heated due to the different _____ rates of the metals.

25 The Second Law of Thermodynamics would back up this statement: Heat wil not, by itself, flow from a cold object to a warmer object. True or False (circle one)

26 The total energy of a system, E, consists of three types of energy. Which of the following is NOT one of them. (circle one)

U, Internal Energy
R, Resting Energy
V, Potential Energy
K, Kinetic Energy

27 Water boils at _____ degrees on the Fahrenheit scale.

28 Whenever energy is transformed, some of the energy will degenerate to useless forms and is unavailable for doing the same work again. True or False (circle one)

29 A state change from solid to gas is called _____

30 A heat engine has a thermal efficiency of 45%. How much power does the engine produce when heat is transferred into it at a rate of 10^9 kJ/hr? _____

31 What is the terminology used to describe a process that is carried out without any transfer of heat? _____
_____

32 A type of heat transfer that can take place through a vacuum is called _____

33 The SI scale of temperature used in scientific research is the _____ scale.

34 Which of the following is NOT a unit of heat? (circle one)

joule
fahrenheit
calorie
btu

35 BTU is the abbreviation for _____

36 Who invented the first closed tube thermometer in 1713?_____

37 Convert 200 degrees on the Celsius scale to the Newton scale. _____

38 At what temperature (in Kelvin) would 4.0 moles of hydrogen gas in a 100 liter container exert a pressure of 1.0 atmospheres? _____

39 At what temperature in ^oF does the Rankine scale begin?_____

40 Metals conduct both heat and cold very well. True or False (Circle one)

41 At standard temperature and pressure, what is the heat of formation of water vapor?_____

42 In the formula $Q = \Delta U + W$, the U stands for _____

43 Which absorbs more radiant energy? (circle one)

Dark objects
Light objects

44 What type of heat transfer causes a frying pan handle to get warm?_____

45 The transfer of heat between materials that are in direct contact is called _____

46 The Second Law of Thermodynamics would back up this statement: Natural systems tend to proceed towards a state of greater order. True or False (circle one)

47 What is the ideal efficiency of a heat engine that has a hot reservoir at 500K and a cold reservoir of 200K? _____

_____

48 A very poor conductor such as wood or styrofoam is known as a(n) _____ because they delay the transfer of heat.

49 When heat is absorbed by a system from its surroundings, the value of heat Q is a positive value? True or False (Circle one)

50 The Second Law of Thermodynamics would back up this statement: Heat can be completely changed into work. True or False (circle one)

51 A state change from gas to liquid is called _____

52 A 12g peice of metal (with specific heat of 0.277cal/g ^{o}C) is warmed so that its temperature increases by 7.11^{o}C. How much heat (in calories) was transferred into it? _____

53 What is the term for the amount of disorder in a system?_____

54 The First Law of Thermodynamics would tell you that you can't get more work out of a machine than the amount of energy that you put in. True or False (circle one)

55 Convert 128 degrees on the Romer scale to the Fahrenheit scale. _____

56 A state change from liquid to gas is called _____

57 Not including the Zeroth Law, how many laws of thermodynamics exist?_____

58 At 17^{o}C, a 0.80 mole sample of a gas exerts a pressure of 1.2 atmospheres. What is the volume (in liters) of the container? _____

59 What is the Law of Constant Heat Summation, which is used to calculate the change in the amount of heat within a system, better known as?_____

60 Name the five states of matter

1. _____
2. _____
3. _____
4. _____
5. _____

61 What type of reaction produces heat?_____

62 A state change from solid to liquid is called _____

63 A Carnot engine operates using a 527^{o}C energy reservoir and a 27^{o}C energy reservoir. The thermodynamic efficiency of this engine is _____ percent.

64 Convert 600 degrees on the Rankine scale to the Delisle scale. _____

65 The Second Law of Thermodynamics would back up the statement that perpetual motion machines are possible. True or False (circle one)

66 What percentage of the electrical energy that flows through a common incandescent light bulb becomes heat energy?

_____

67 A substance with mass 10kg gains 106.5kJ of heat when its temperature increases 15K. What is the substance's specific heat? _____

68 How many moles of oxygen must be placed in a 3.0 liter container in order to exert a pressure of 2.0 atmospheres at 25^{o}C? _____

69 Chemical reactions that absorb heat energy are called _____ and have a _____ enthalpy. (circle one)

exothermic, positive
exothermic, negative
endothermic, positive

70 A system's initial energy is 27Joules. Heat is added to the system. If the final internal energy reached 34Joules, and the system does 26Joules of work, how much heat was added to the system? _____

71 The term thermodynamics was coined by _____ in 1849 to designate the science of relations between heat and power.

Tie Breaker

Hamburgers are cooked on the grill until they reach a temperature of 175°C. Once cooked, they are placed on a plate to cool at room temperature, 25°C. If the hamburger's k value is 0.062, what will their temperature be (in °C) after 10 minutes resting on the plate? _____

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Team Name: ANSWER KEY Score: _____

Team Members: _____

BE SURE TO USE THE CORRECT NUMBER OF SIGNIFICANT FIGURES AND SI UNITS.

1 What absorbs more radiant energy? (circle one)
- Shiny objects
- (Dull objects)

2 Who first used the term "entropy"? CARNOT

3 Convert 70°C to Kelvin. 343

4 A mathmatical approach to the First Law of Thermodynamics is: (circle one)
- U = P + Q
- Q = W + E
- (U = Q - W)

5 Which of the reversible processes listed below are used to form a Carnot cycle? (circle one)
- Isometric, isobaric
- Isometric, adiabatic
- Isobaric, adiabatic
- (Isothermal, adiabatic)

6 Which will be cooler if left in the sun? (circle one)
- (A shiny object)
- A dull object

7 What type of heat transfer involves electromagnetic waves in the infrared region? RADIATION

8 A state change from liquid to solid is called FREEZING

9 In the formula Q = ΔU + W, the Q stands for HEAT

10 Give three methods of heat transfer. CONVECTION, CONDUCTION, RADIATION

11 Water freezes at 32 degrees on the Fahrenheit scale.

12 The Second Law of Thermodynamics would back up this statement: Disorganized energy can be changed to orderly usable energy only by doing work. True or False (circle one)

13 Which will be hotter if left in the sun? (circle one)
- A light colored car
- (A dark colored car)

14 The Third Law of Thermodynamics refers to a state known as "absolute zero". This is the bottom of which temperature scale? KELVIN

15 In thermodynamics there are three types of systems. An isolated system does not allow any heat and matter transfer between the system and its surroundings. An open system allows both heat and matter transfer. What is the name given to the system that allows heat transfer but prevents matter transfer? CLOSED SYSTEM

16 Pressure, volume, internal energy, entropy, and Gibb's free energy are all state functions because their values are dependent only on the initial and final state of the system, regardless of the route taken. Non-state functions are so-called because their values depend on the route taken. What are two examples of non-state functions? (circle one)
- Enthalpy and heat
- (Work and heat)
- Work and temperature
- Enthalpy and temperature

17 The Second Law of Thermodynamics would back up this statement: In a piston, as heat is added, all of the moleculeswill move in the same direction, pushing the piston up. True or (False) (circle one)

18 Consider three systems, X, Y, and Z. If X and Z are in thermal equilibrium, and Y and Z are in thermal equilibrium, then X and Y will also be in thermal equilibrium. This is known as the Zeroth Law of Thermodynamics. (True) or False (Circle one)

19 What temperature scale assigns 0 degrees as the freezing point of water, and 100 degrees as the boiling point of water? CELSIUS

20 The Third Law of Thermodynamics says that as the temperature of a substance approaches absolute zero, the entropy approaches zero. (True) or False (circle one)

21 A form of heat transfer that occurs by currents in a fluid (gas or liquid) is called CONVECTION

22 If the internal energy of a system increases, then the TEMPERATURE of the system will increase.

23 In the formula $Q = \Delta U + W$, the W stands for WORK DONE BY THE SYSTEM

24 Two strips of different metals, permanently bonded together, will curve when heated due to the different EXPANSION rates of the metals.

25 The Second Law of Thermodynamics would back up this statement: Heat wil not, by itself, flow from a cold object to a warmer object. (True) or False (circle one)

26 The total energy of a system, E, consists of three types of energy. Which of the following is NOT one of them. (circle one)

U, Internal Energy
(R, Resting Energy)
V, Potential Energy
K, Kinetic Energy

27 Water boils at 212 degrees on the Fahrenheit scale.

28 Whenever energy is transformed, some of the energy will degenerate to useless forms and is unavailable for doing the same work again. (True) or False (circle one)

29 A state change from solid to gas is called SUBLIMATION

30 A heat engine has a thermal efficiency of 45%. How much power does the engine produce when heat is transferred into it at a rate of 10^9 kJ/hr? 125MW

31 What is the terminology used to describe a process that is carried out without any transfer of heat? ADIABATIC

32 A type of heat transfer that can take place through a vacuum is called RADIATION

33 The SI scale of temperature used in scientific research is the KELVIN scale.

34 Which of the following is NOT a unit of heat? (circle one)

joule
(fahrenheit)
calorie
btu

35 BTU is the abbreviation for BRITISH THERMAL UNIT

36 Who invented the first closed tube thermometer in 1713? FAHRENHEIT

37 Convert 200 degrees on the Celsius scale to the Newton scale. 66°N

38 At what temperature (in Kelvin) would 4.0 moles of hydrogen gas in a 100 liter container exert a pressure of 1.0 atmospheres? 305K

39 At what temperature in °F does the Rankine scale begin? -459°F

40 Metals conduct both heat and cold very well. True or (False) (Circle one)

41 At standard temperature and pressure, what is the heat of formation of water vapor? -241KJ/MOLE

42 In the formula $Q = \Delta U + W$, the U stands for INTERNAL ENERGY

43 Which absorbs ~~more~~ radiant energy? (circle one)

(Dark objects)
Light objects

44 What type of heat transfer causes a frying pan handle to get warm? CONDUCTION

45 The transfer of heat between materials that are in direct contact is called CONDUCTION

46 The Second Law of Thermodynamics would back up this statement: Natural systems tend to proceed towards a state of greater order. True or (False) (circle one)

47 What is the ideal efficiency of a heat engine that has a hot reservoir at 500K and a cold reservoir of 200K? 60%

48 A very poor conductor such as wood or styrofoam is known as a(n) INSULATOR because they delay the transfer of heat.

49 When heat is absorbed by a system from its surroundings, the value of heat Q is a positive value? (True) or False (Circle one)

50 The Second Law of Thermodynamics would back up this statement: Heat can be completely changed into work. True or (False) (circle one)

51 A state change from gas to liquid is called CONDENSATION

52 A 12g peice of metal (with specific heat of 0.277cal/g °C) is warmed so that its temperature increases by 7.11°C. How much heat (in calories) was transferred into it? 24CAL

53 What is the term for the amount of disorder in a system? ENTROPY

54 The First Law of Thermodynamics would tell you that you can't get more work out of a machine than the amount of energy that you put in. (True) or False (circle one)

55 Convert 128 degrees on the Romer scale to the Fahrenheit scale. 445°F

56 A state change from liquid to gas is called VAPORIZATION

57 Not including the Zeroth Law, how many laws of thermodynamics exist? 3

58 At 17°C, a 0.80 mole sample of a gas exerts a pressure of 1.2 atmospheres. What is the volume (in liters) of the container? 16 LITERS

59 What is the Law of Constant Heat Summation, which is used to calculate the change in the amount of heat within a system, better known as? HESS' LAW

60 Name the five states of matter

1. SOLID
2. LIQUID
3. GAS
4. PLASMA
5. SUPERFLUID (BOSE-EINSTEIN CONDENSATE)

61 What type of reaction produces heat? EXOTHERMIC

62 A state change from solid to liquid is called MELTING

63 A Carnot engine operates using a 527°C energy reservoir and a 27°C energy reservoir. The thermodynamic efficiency of this engine is 62.5 percent.

64 Convert 600 degrees on the Rankine scale to the Delisle scale. 60°De

65 The Second Law of Thermodynamics would back up the statement that perpetual motion machines are possible. True or (False) (circle one)

66 What percentage of the electrical energy that flows through a common incandescent light bulb becomes heat energy? 100%

67 A substance with mass 10kg gains 106.5kJ of heat when its temperature increases 15K. What is the substance's specific heat? 0.71 J/g°C

68 How many moles of oxygen must be placed in a 3.0 liter container in order to exert a pressure of 2.0 atmospheres at 25°C? 0.25 MOLES

69 Chemical reactions that absorb heat energy are called _____ and have a _____ enthalpy. (circle one)

exothermic, positive
exothermic, negative
(endothermic, positive)

70 A system's initial energy is 27Joules. Heat is added to the system. If the final internal energy reached 34Joules, and the system does 26Joules of work, how much heat was added to the system? 33JOULES

71 The term thermodynamics was coined by JOULE in 1849 to designate the science of relations between heat and power.

Tie Breaker

Hamburgers are cooked on the grill until they reach a temperature of 175°C. Once cooked, they are placed on a plate to cool at room temperature, 25°C. If the hamburger's k value is 0.062, what will their temperature be (in °C) after 10 minutes resting on the plate? 105°C

(3) $K = C + 273$

$K = 70 + 273 = 343$

(30) $1 \times 10^9 \frac{KJ}{HR} \Rightarrow \frac{10^9}{3600} = 278MW$

$W = \eta Q = (0.45)(278) = 125MW$

(37) $N = C \times {}^{33}/_{100} = 200 \times {}^{33}/_{100} = 66°N$

(38) $PV = nRT \Rightarrow T = \frac{PV}{nR} = \frac{(1)(100)}{(4)(0.0821)} = 305K$

(39) RANKINE SCALE BEGINS AT ABSOLUTE ZERO, 0°R

$R = °F + 459 \Rightarrow F = R - 459$

SINCE $R = 0$, $F = -459$

(47) $\eta = 1 - \frac{T_c}{T_h}$

WHERE T_C IS THE COLD SINK IN K AND T_H IS THE HOT SOURCE IN K

$\eta = 1 - \frac{200}{500} = 1 - 0.4$

$= 0.6$

$\eta = 60\%$

(52) $Q = mc\Delta t = (12)(0.277)(7.11) = 24\,CAL$

(55) $F = (R_o - 7.5)^{24/7} + 32$

$= (128 - 7.5)^{\frac{24}{7}} + 32 = 445°F$

(58) $PV = nRT \Rightarrow V = \frac{nRT}{P} = \frac{(0.8)(0.0821)(290)}{1.2}$ ($17°C = 290K$)

$V = 16\,L$

(63) $27°C = 300K$
$527°C = 800K$ $\quad \eta = 1 - \left(\frac{T_L}{T_H}\right) = 1 - \frac{300}{800} = 62.5\%$

(64) $°De = (671.7 - [°R]) \times \frac{5}{6}$

$= (671.7 - 600) \times \frac{5}{6} = 60°De$

(67) $Q = mc\Delta t \Rightarrow c = Q/m\Delta t = \frac{106.5 \times 10^3}{(10000)(15)} = 0.71 \frac{J}{g°C}$

(68) $25°C = 298K$

$PV = nRT \Rightarrow n = \frac{PV}{RT} = \frac{(2)(3)}{(0.0821)(298)}$

$n = 0.25\,MOLE$

(70) $U_1 = 27J$, $U_2 = 34J$, $W = 26J$

$\Delta U = U_2 - U_1 = 7J$

$Q = U + W$

$= 7 + 26 = 33\,JOULE$

TIE BREAKER

$$T_F = T_A + (T_0 - T_A)e^{(-k\Delta t)}$$

WHERE T_F IS UNKNOWN

$T_A = 25$

$T_0 = 175$

$K = 0.062$

$t = 10$

$$T_F = 25 + (175 - 25)e^{-(0.062)(10)}$$

$$T_F = 25 + 150e^{-0.62}$$

$$= 25 + 150(0.53)$$

$$\cong 105^\circ C$$