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Physics 117 Exam III, Cover Page

A) GENERAL INSTRUCTIONS

This exam consists of 60 questions worth two points each for a maximum of 120 points.

ALL ANSWERS MUST BE ENTERED INTO THE NCS ANSWER SHEET BY MEANS OF HEAVY BLACK MARKS WITH A NUMBER 2 PENCIL. (Only a pencil mark will work; the optical scanner cannot read inked answers no matter what color or how dark.)

The questions are numbered from 1 to 60: make sure you enter your single letter answer into the answer line with the same number as the question you are answering.

Only the computer readable NCS answer sheet will be handed in. Keep this exam for you future use.

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B) PREPARE YOUR ANSWER SHEET IN ADVANCE:

1) SIGN YOUR PERSONAL SIGNATURE INTO THE TOP MARGIN ABOVE THE NAME BOX.
2) PRINT YOUR NAME, **FAMILY NAME FIRST**, INTO THE BOXES PROVIDED AND DARKEN THE CIRCLE FOR THE CORRESPONDING LETTER BELOW EACH BOX
3) INSERT YOUR STUDENT ID NUMBER UNDER "IDENTIFICATION NUMBER" AND DARKEN THE CORRESPONDING CIRCLES BELOW EACH NUMBER.
4) MAKE NO STRAY MARKS ON THE ANSWER SHEET AND ERASE CLEANLY IF NECESSARY.

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C) GENERAL ADVICE

Many students will not have time to finish this exam if they proceed at a leisurely pace. Therefore it is probably advantageous to earmark time-consuming items for later attention and skip forward to questions that can be answered more easily. No subtractions will be made for wrong answers, so that last minute best guessing is probably an advantageous strategy.

IF YOU NEED HELP, ASK!.....AND ASK EARLY RATHER THAN LATE.

ALSO FOR FAIRNESS' SAKE, PLEASE STOP WRITING WHEN THE EXAM ENDS. A PENALTY OF 8% OF THE RAW SCORE MAY BE IMPOSED UPON STUDENTS WHO TRY TO TAKE UNFAIR ADVANTAGE OF THE COLLECTION PROCESS BY CONTINUING TO WRITE AFTER THE END HAS BEEN ANNOUNCED.

Multiple Choice

Insert into your NCS answer sheet the letter of the single choice that best completes the statement or answers the question.

1. According to the special theory of relativity, all laws of nature are the same in reference systems which _____ relative to an inertial system.
   a. have a constant acceleration
   b. move at a constant velocity
   c. move in ellipses
   d. move in circles at a constant speed
   e. None of the above insertions yields a true statement.

2. The first postulate of special relativity
   a. says that there is no absolute reference frame.
   b. is a reaffirmation of the Galilean principle of relativity.
   c. states that the laws of physics are the same in all inertial reference systems.
   d. applies also to the implication of Maxwell's equations that the speed of light in vacuum is constant.
   e. All of these statements are true.

3. In his theory of special relativity, Einstein
   a. abandoned the Galilean principle of relativity.
   b. abandoned Maxwell's equations for electricity and magnetism.
   c. reconciled the apparent conflict between the Galilean principle of relativity and Maxwell's equations.
   d. postulated the existence of an absolute reference system.
   e. postulated the Principle of Equivalence

4. What was the purpose in postulating the existence of the ether?
   a. To specify which reference system was the absolute one.
   b. To account for the slowing of the earth in its annual journey around the sun.
   c. To provide the medium through which light traveled.
   d. To account for the time difference measured in the Michelson-Morley experiments.
   e. To preserve the status quo of Galilean Relativity.

5. The second postulate of special relativity does NOT require that the speed of light
   a. is a constant in a vacuum.
   b. is always constant in any medium and equal to c.
   c. is independent of the motion of the source.
   d. is independent of the motion of the receiver.
   e. In fact the second postulate requires all of the above.

6. As a space ship approaches you in outer space at 60% of the speed of light, its rotating beacon sends out a pulse of light. You measure the speed of this light to be
   a. 40% of c
   b. 60% of c
   c. 100% of c
   d. 140% of c
   e. 160% of c

7. Which of the following concepts is NOT a relative one? That is, about which will observers in different inertial systems agree in their observations?
   a. simultaneity of events at separated locations
   b. rate at which clocks run
   c. the aging process
   d. synchronization of clocks
   e. None of the above: the observers will disagree about all of them.

8. As a friend passed you at a very high speed, she reported that she simultaneously exploded a firecracker at each end of her skateboard. Which one exploded first from your point of view?
   a. the one at the front
   b. the one at the back
   c. They exploded simultaneously.
   d. The answer depends on the speed of the skateboard.
   e. None of the above is a correct answer to the question.

9. A rocket ship is 80 m long when measured at rest. What is its length as measured by an observer who sees the rocket ship moving past at 99% of the speed of light? The relativistic adjustment factor, $\gamma = 1/(1-v^2/c^2)^{1/2}$, for 0.99c is 7.09.
   a. 567.2 m
   b. 80.8 m
   c. 80.0 m
   d. 79.2 m
   e. None of the above.

10. The twin paradox involves the situation in which one twin remains on earth while the other makes a trip to a distant location at the same constant speed, comparable to the speed of light, in both directions. When the twins are reunited on earth, we discover that the twin who _____ is younger than the other.
   a. remained on earth, because he did not undergo any acceleration.
   b. made the trip, because he had to accelerate to turn around.
   c. Actually, they are the same age, because the speed was held constant out and back.
   d. We cannot say until we know the details of the turnaround.
   e. None of the above is true.

11. An electron is being accelerated by a constant force to nearly the speed of light. Which of the following is NOT true?
   a. Its kinetic energy increases steadily.
   b. Its momentum increases at a constant rate.
   c. It can approach but not exceed the speed of light.
   d. Its total energy continually increases.
   e. All of the above are true.

12. If inertial mass and gravitational mass were NOT the same,
   a. the law of universal gravitation would need to be modified.
   b. Newton's second law would need to be modified.
   c. all objects falling in a vacuum near the earth's surface would no longer experience the same acceleration.
   d. all objects falling in a vacuum near the earth's would no longer experience the same force.
   e. All of the above statements are true.

13. The law of definite proportions states that _____ have definite _____ ratios of their constituent elements.
    a. compounds ... mass
    b. compounds ... volume
    c. mixtures ... mass
    d. mixtures ... volume
    e. None of the above, the law of definite proportions is about volumes, not masses.

14. One mole of water molecules consists of 1 mole of oxygen atoms(A=16) and 2 moles of hydrogen atoms (A=1) . If you combine 1 kg of oxygen with 1 kg of hydrogen to make water, how many moles of water can you make?
    a. 3
    b. 62.5
    c. 500
    d. 562.5
    e. None of the above is within 10% of the correct answer.

15. Two gases are kept at the same temperature. If the molecules of gas A have 4 times the mass of those of gas B, what is the ratio of the mean squared speed of the A molecules to that of the B molecules?
    a. 4
    b. 2
    c. 1
    d. 1/2
    e. 1/4

16. One liter of nitrogen (N) combines with 3 liters of hydrogen (H) to form 2 liters of ammonia. If the molecules of nitrogen and hydrogen have 2 atoms each, how many atoms of hydrogen and nitrogen are there in 1 molecule of ammonia?
    a. 2 H and 1 N
    b. 2 H and 2 N
    c. 3 H and 1 N
    d. 3 H and 2 N
    e. 6H and 2 N

17. Which of the following is NOT assumed in our model of the ideal gas? The gas particles
    a. rebound elastically when they collide with the container wall.
    b. have no internal structure.
    c. are indestructible.
    d. do not interact except when they collide.
    e. All of the above are properties of our ideal gas.

18. The pressure that a molecular gas exerts on the walls of its container increases with
    a. the average magnitude of the momentum of the molecules.
    b. the speed with which the molecules travel to their next collision with the wall.
    c. the density of gas molecules .
    d. the average kinetic energy of the gas molecules.
    e. All of the above statements are true.

19. If a liter of gas has a pressure of 0.5 atmosphere, what will the pressure be if the average kinetic energy of the molecules is doubled, while the volume reduced to half its original value?
    a. 0.5 atm
    b. 1 atm
    c. 2 atm
    d. 4 atm
    e. None of the above is within 10%.

20. The two fixed points used to define the modern Fahrenheit temperature scale are those of
    a. boiling water and a mixture of ice and salt.
    b. the human body temperature and a mixture of ice and salt.
    c. the human body temperature and freezing water.
    d. boiling water and freezing water.
    e. None of the above

21. What Celsius temperature corresponds most closely to 77° F?
    a. 138.6° C
    b. 81.0° C
    c. 60.5° C
    d. 42.8° C
    e. 25.0° C

22. Which of the following doubles with a doubling of the absolute temperature of an ideal gas?
    a. average momentum
    b. average speed
    c. average velocity
    d. average kinetic energy
    e All of the above.

23. Which of the following doubles with a doubling of the Celsius temperature of an ideal gas?
    a. average momentum
    b. average speed
    c. average kinetic energy
    d. product of pressure and volume
    e. None of the above

24. The pressure in a container filled with gas increases when it is heated because
    a. the walls do work on the gas.
    b. the average momentum of a gas particle increases.
    c. the number of gas particles increases.
    d. the volume of the gas decreases.
    e. The average momentum change in a collision with the wall increases.

25. In radiative heat transfer, thermal energy is transported by
    a. the movement of a fluid.
    b. the collisions of particles.
    c. electromagnetic fields.
    d. the propagation of sound waves.
    e. physical vibrations of the intervening medium.

26. Joule's experiments with hanging weights turning paddle wheels in water
    a. showed that heat was not a fluid.
    b. showed that 4.2 joules of work are equivalent to 1 calorie of heat.
    c. were used to define the calorie.
    d. showed that heat could be converted 100% to mechanical energy.
    e. None of the above.

27. Two objects are in thermal equilibrium if
    a. they have the same temperature.
    b. they are each in thermal equilibrium with the same third object.
    c. they are in thermal contact and there is no net flow of thermal energy.
    d. All of the above are true
    e. None of the above is true.

28. The first law of thermodynamics
    a. is a restatement of the law of conservation of energy.
    b. allows that work can be completely converted into internal energy.
    c. treats heat as another form of energy.
    d. guarantees that the work extracted by a cyclic heat engine can never exceed the heat inserted.
    e. All of the above statements are true of the first law.

29. If a system has no change in internal energy, we can say that
    a. the system lost no heat.
    b. no work was done on the system.
    c. the amount of work done by the system was equal to the heat gained.
    d. the change in heat energy produced a temperature change.
    e. None of the above assertions can be made on the basis of this statement.

30. Which of the following statements about a cup of water and a gallon of water at the same temperature is correct?
    a. They will transfer the same heat energy to a third object at lower temperature.
    b. They have the same internal energies.
    c. The average molecular speed in the gallon is less than that in the cup
    d. The average molecular speed in the cup of water is less that that in the gallon.
    e. None of the above.

31. When an ideal gas was compressed, its internal energy increased by 80 J and it gave off 30 J of heat. How much work was done on the gas?
    a. 30 J
    b. 50 J
    c. 80 J
    d. 110 J
    e. None of the above.

32. The third law of thermodynamics
    a. is a restatement of the law of conservation of energy.
    b. says that heat cannot be completely converted to mechanical energy.
    c. says that we can never reach the absolute zero of temperature.
    d. says that all motion ceases at absolute zero.
    e. guarantees that temperature is useful for predicting heat transfer.

33. Why do climates near the coasts tend to be more moderate than near the middle of the continent?

    a. Because water has a high latent heat of vaporization.
    b. Because the coasts have lower elevations, and cool air flows downhill.
    c. Because water has a relatively high specific heat.
    d. Because it rains a lot on the coasts.
    e Because water has a high latent heat of fusion

34. Aluminum and air have almost the same specific heats. Therefore, 100 calories of heat will raise the temperature of 1 liter of aluminum _____ 1 liter of air. (Assume T = 20°C, and P = 1 atm.)
    a. much more than
    b. slightly more than
    c. about the same as
    d. slightly less than
    e. much less than

35. If it takes 3400 cal to raise the temperature of a 700-g statue by 44° C, what is the specific heat of the material used to make the statue?
    a. 213.7 cal/g-°C
    b. 77.3 cal/g-°C
    c. 4.86 cal/g-°C
    d. 0.11 cal/g-°C
    e. None of the above is within 10% of the correct answer.

36. In convection, thermal energy is transported by
    a. the movement of a fluid.
    b. the collisions of particles.
    c. electromagnetic fields.
    d. the propagation of sound waves.
    e. physical vibrations of the intervening medium.

37. It is NOT possible to convert completely
    a. heat into internal energy.
    b. mechanical energy into internal energy.
    c. internal energy into mechanical energy.
    d. work into heat.
    e. All of the above transformations are in fact possible.

38. Any actual cyclic heat engine
    a. converts thermal energy into mechanical energy.
    b. always exhausts thermal energy in each cycle.
    c. conforms to the first law of thermodynamics.
    d. can never be 100% efficient.
    e. All of the above statements are true of any actual heat enegine.

39. The second law of thermodynamics says
    a. that the energy of an isolated system is conserved.
    b. that it is impossible to build a heat engine that can do mechanical work by extracting thermal energy that does not also exhaust heat to the surroundings.
    c. that it is impossible to reach the absolute zero of temperature.
    d. that it is impossible to build a heat engine that does more mechanical work than the thermal energy it consumes.
    e. None of the above is an implication of the second law.

40. An engine takes in 12,000 cal of heat and exhausts 4000 cal of heat each minute it is running. How much work does the engine do each minute?
    a. 2000 cal
    b. 4000 cal
    c. 6000 cal
    d. 8000 cal
    e. 10,000 cal

41. Which of the following restrictions do the (four) laws of thermodynamics place on any prospective perpetual motion machine?
    a. It cannot exhaust heat at absolute zero temperature.
    b. Energy must be conserved.
    c. Thermal energy cannot be completely converted to mechanical energy.
    d. It cannot move heat from a cooler region to a hotter region without consuming work.
    e. All of the above restrictions are placed on perpetual motion machines by the laws of thermodynamics.

42. A heat engine takes in 600 J of energy at 1000 K and exhausts 300 J at 400 K. What is the maximum theoretical efficiency (i.e., the Carnot efficiency) for this engine, and what is its actual efficiency, respectively ?
    a. 40% and 60%, respectively.
    b. 40% and 50%, respectively.
    c. 50% and 50%, respectively.
    d. 60% and 50%, respectively.
    e. 60% and 40%, respectively.

43. An engineer has designed a machine to produce electricity by using the difference in the temperature of ocean water at depths of 0 and 50 m. If the surface temperature is 20° C and the temperature at 50 m below the surface is 11° C, what is the Carnot maximum efficiency of this machine?
    a. 97 %
    b. 55 %
    c. 45 %
    d. 3 %
    e. None of the above is within ±1% of the correct answer.

44. A refrigerator extracts 1000 J of energy from a cold region and exhausts 1300 J of energy to a hot region. What minimum amount of work is required to achieve this?
    a. 2300 J
    b. 1300 J
    c. 1000 J
    d. 300 J
    e. None of the above is correct within 10%

45. How many different outcomes are there for the flipping of five different coins, and what fraction of those yields the most ordered result (i.e., all heads or all tails), respectively?
    a. 5 and 50%, respectively.
    b. 10 and 25%, respectively.
    c. 16 and 12.5%, respectively.
    d. 32 and 6.25%, respectively.
    e. None of the above are correct within ± 1%.

46. A ringing bell is inserted into a large glass of water. The bell and the water are initially at the same temperature and are insulated from their surroundings. Eventually the bell stops vibrating and the water comes to rest and to thermal equilibrium . Which of the following statements is FALSE?
    a. The mechanical energy of the bell has been completely converted into internal energy of the combined system.
    b. The final temperature of the combined system is lower than the initial temperature.
    c. The entropy of the combined system has increased.
    d. The total energy of the system has not changed.
    e. None. All of the above statements are in fact true.

___ 47. A cold piece of metal is dropped into an insulated container of hot water. After the system has reached its equilibrium temperature, the
    a. entropy of the metal has increased.
    b. entropy of the water has decreased.
    c. net change in entropy of the system is positive.
    d. The final temperature of the system lies between the initial temperatures of the metal and the initial tempeature water.
    e. All of the above statements are true.

48. Consider the human body to be a heat engine with an efficiency of 20%. This means that
    a. only 20% of the food you eat is digested.
    b. 80% of the energy you obtain from food is destroyed.
    c. you should spend 80% of each day lying quietly without working.
    d. only 20% of the energy you obtain from food can be used to do physical work.
    e. None of the above.

(The remaining problems may require somewhat more numerical calculation than the preceding ones.)

49. A train is traveling along a straight, horizontal track at a constant speed of 0.8c. A warning light on the ground flashes once each second. An observer in the train measures the time between flashes to be
    a. 0.6 s
    b. 0.8 s
    c. 1.0 s
    d. 1.25
    e. 1.67 s

50. Two objects (e.g. an electron and a positron), each of rest mass, m, and each traveling with a speed of 0.6c, collide head-on and annihilate in the collision entirely into electromagnetic radiation. How much energy is emitted as radiation?
    a. $E = mc^2$
    b. $E = 1.25\ mc^2$
    c. $E = 1.67\ mc^2$
    d. $E = 2.0\ mc^2$
    e. $E = 2.5\ mc^2$
    f. $E = 3.34\ mc^2$

51. If the speed, v, of a particle of rest mass m increases from 0.99999c to 0.9999999c, {so that v/c increases from $(1- 10^{-5})$ to $(1-10^{-6})$}, by what factor does its total energy increase, most nearly ?

    a. 1.000 001
    b. 1.000 01
    c. 3.3
    d. 4.67
    e. 10

52. Two liters of an ideal gas is heated from 300 °C to 600 °C while the pressure is maintained at 1 atm. What is the final volume of the gas, most nearly?
    a. 1 liters
    b. 2 liters
    c. 3 liters
    d. 4 liters
    e. None of the above is within 10% of the correct answer

53. You exert a force of 30 N on the head of a thumbtack. The head of the thumbtack has a radius of 3 mm. What is the pressure on your thumb, most nearly? (1 Pa = $1N/m^2$.)
    a. 10^{-6} Pa
    b. 10^{-5}Pa
    c. 1 Pa
    d. 10^5 Pa
    e. 10^6 Pa

54. A hypothetical balloon filled with an ideal gas has a volume of 10^5 liters at 27°C under one atmosphere of pressure. At what temperature, most nearly, will its volume be 10^4 liters under one atmosphere of pressure?
    a. -273°C
    b. -243°C
    c. -203°C
    d. -163°C
    e. -123°C

55. The latent heat of melting for water is 334 kJ/kg, and its specific heat is 4.2kJ/kg-°C. How much energy would it take to melt 3 kg of ice at 0° C to form water at 20° C?
    a. 84 kJ
    b. 252 kJ
    c. 418 kJ
    d. 1002 kJ
    e. 1254 kJ

56. If 200 g of water at 100° C and 100 g of ice at 0° C are mixed with 300 g of water at 50° C in a completely insulated container, what is the final equilibrium temperature, most nearly ? Recall that the latent heat of fusion of ice is 80 cal/g.
    a. 45° C
    b. 54° C
    c. 58° C
    d. 70° C
    e. None of the above is within 10% of the correc answer.

57. A steel railroad rail is 55.6 m long. How much does its length change during a day when the low temperature is 50° F (18° C) and the high temperature is 91° F (33° C)? Steel has a coefficient of thermal expansion, $\alpha = 1.2 \times 10^{-5}$ /°C
    a. 0.001 cm
    b. 0.01 cm
    c. 0.1 cm
    d. 1.0 cm
    e. 10.0 cm

58. An ideal heat engine has a theoretical efficiency of 40% and an exhaust temperature of 27° C. What is its input temperature, most nearly ?
    a. 227° C
    b. 477° C
    c. 600° C
    d. 750° C
    e. None of the above is within 10% of the correct answer

59. A cool (27° C) piece of metal is dropped into an insulated container of hot (127° C) oil. Suppose that in the first ten seconds 800 cal of heat is transferred from the oil to the metal, but that the changes in both temperatures are negligible during that time. Then the increase in entropy was most nearly
    a. 29.63 cal/° C
    b. 23.33 cal/° C
    c. 6.30 cal/° C
    d. 2.67 cal/K
    e. 2.00 cal/K
    f. 0.67 cal/K

60. An air-conditioner mechanic is testing a unit by running it on the workbench in an isolated room. The unit removes 100 cal/min from the refrigerated chamber, utilizing a work input of 420 J/min. By how much does the internal energy of the room outside the refrigerated chamber change, most nearly, in each minute?
    a. It decreases by 520 J/min.
    b It decreases by 200 cal/min
    c. It decreases by 520 cal/min.
    d. It stays the same.
    e. It increases by 520 cal/min
    f. It increases by 200 cal/min.
    g. It increases by 520 J/min

End of exam