

73. What is the frequency of the minute ~~hour~~<sup>hand</sup> on a clock?
- 3600 Hz
  - 60 Hz
  - 1 Hz
  - $2 \times 10^{-2}$  Hz
  - $3 \times 10^{-4}$  Hz
74. Which of the following sets of parameters all affect the period of a pendulum? (M = Mass, L = Length, and g = acceleration due to gravity)
- (M, L and g)
  - (M and L)
  - (M and g)
  - (L and g)
  - L only
  - None of the above.
75. For small amplitudes the period of a pendulum is \_\_\_\_\_ the acceleration due to gravity.
- proportional to
  - proportional to the square root of
  - inversely proportional to the square root of
  - inversely proportional to
  - None of the above.
76. Which of the following expressions gives the correct relationship between the wavelength, the period or frequency, and the velocity for a periodic wave?
- $v = \lambda T$
  - $v = \lambda f$
  - $v = \lambda / f$
  - $v = fT$
  - None of the above.
77. The ratio of the speed of a periodic sound wave of frequency of 220 Hz to that of a wave with a frequency of 440 Hz is, most nearly:
- 0.5
  - 0.71
  - 1.0
  - 1.41
  - 2.0
  - None of the above is correct within 10%.
78. A periodic wave on a string has a wavelength of 30 cm and a frequency of 4 Hz. What is the speed of the wave?
- 7.5 cm/s
  - 30 cm/s
  - 60 cm/s
  - 120 cm/s
  - None of the above is correct within 10%.

79. The fundamental wavelength for standing waves on a rope fixed at both ends is the length of the rope.
- four times
  - two times
  - the same as
  - one-half
  - one-fourth
  - None of the above
80. Two point sources produce waves of the same wavelength and are completely in-phase (that is, both sources produce maximal crests at the same time). At a point that is one-half wavelength farther from one source than the other, you would expect to find
- an amplitude equal to twice that of one wave alone.
  - an amplitude equal to that of one wave alone.
  - approximately zero amplitude.
  - An intensity equal to four times that of each wave.
  - None of the above
81. Which of the following are NOT electromagnetic waves?
- radio
  - TV
  - infrared light
  - microwaves
  - X-rays
  - All of the above are electromagnetic waves.
82. What is the wavelength of the carrier wave for an AM radio station located at 1000 kHz on the dial?
- 3 cm
  - 3 m
  - 30 m
  - 300 m
  - None of the above is correct within 10%.
83. The periodic table arranges the elements according to
- the order in which they were discovered.
  - their chemical properties.
  - their relative abundances.
  - alphabetical order.
  - None of the above.
84. Which is a correct observation of what happened in our cathode ray tube demonstrations?
- The end of the glass tube opposite the cathode glows.
  - A metal cross casts a shadow by blocking the cathode rays.
  - The cathode rays are seen only when an accelerating voltage is applied
  - The cathode ray stream is deflected by an magnetic field.
  - All of the above.

85. Rutherford's model predicted that atoms should be unstable (the electrons should spiral into the nucleus) over very short time periods. What caused this instability in Rutherford's model?
- The positive charge in the nucleus was too far from the electrons to hold them in orbit.
  - The attractive force between the positive nucleus and the electrons would pull them together.
  - An accelerating charge must radiate energy.
  - Nature abhors a vacuum.
  - None of the above.
86. You measure the brightness of two different hot objects; first with a blue filter and then with a red filter. You find that object A has a brightness of 25 in the blue and 20 in the red. Object B has a brightness of 12 in the blue and 3 in the red. The brightness units are arbitrary but the same for all measurements. Object A is \_\_\_\_\_ object B.
- cooler than
  - the same temperature as
  - hotter than
  - hotter than B in the red but cooler in the blue, after normalizing the data.
  - There is not enough information to say in these two frequency measurements..
87. When light is incident on a metallic surface, the emitted electrons
- are called photons.
  - have arbitrarily high energies.
  - have a maximum energy that depends on the intensity of the light.
  - Are referred to as cathode rays.
  - None of the above
88. Einstein was able to account for the experimental observations of the photoelectric effect by assuming that
- the metal contained atomic resonators.
  - light is a wave phenomenon.
  - light consists of particle-like wave packets.
  - electrons boil off when they get hot enough.
  - The intensity of the electromagnetic field was the determinant of the electrons' energies.
  - None of the above.
89. A clean surface of potassium metal will emit electrons when exposed to blue light. If the **intensity** of the blue light is increased, the \_\_\_\_\_ of the ejected electrons will also increase.
- maximum kinetic energy
  - number
  - average speed
  - average kinetic energy
  - All of the above quantities increase with intensity.
90. A clean surface of metal will emit electrons when exposed to light. If the color of the light is changed from red to blue without changing the intensity, the \_\_\_\_\_ of the ejected electrons will also increase.
- mass
  - number
  - maximum kinetic energy
  - charge
  - None of the above will occur with the stated change in color.

91. Which of the following lists photons in order of **increasing** energy?
- X ray, radio, infrared, visible, ultraviolet
  - infrared, visible, ultraviolet, X ray, radio
  - radio, infrared, X ray, visible, ultraviolet
  - radio, infrared, visible, ultraviolet, X ray
  - None of the above.
92. Which of the following is **NOT** a feature of the Bohr model of the atom?
- an quantized electron angular momentum
  - electrons in planetary-like orbits
  - quantized energy levels
  - accelerating electrons that do not radiate
  - All of the above are features of the Bohr model.
93. Which of the following is **NOT** considered to be a success of Bohr's theory of the atom?
- Obtaining the numerical values for the spectral lines in hydrogen.
  - Explaining why there are more lines in emission spectra than absorption spectra.
  - Explaining why the frequency distributions in emission spectra are discrete rather than continuous.
  - Providing the general features of the periodic table.
  - All of the above are considered successes of the Bohr theory.
94. In 1923, the French graduate student Louis de Broglie proposed that
- photons behave like particles.
  - electrons behave like waves.
  - the energy levels in atoms are quantized.
  - the behavior of electrons must be explained by quantum mechanics.
  - None of the above.
95. The de Broglie wavelength of a particle with a mass  $m$  and a velocity  $v$  is given by
- $mv$
  - $\lambda/mv$
  - $mv/h$
  - $h/mv$
  - None of the above.
96. Bohr could never really explain why an electron was limited to certain orbits. De Broglie explained this by showing that electrons in Bohr's allowed orbits
- form standing-wave patterns about the nucleus.
  - have elliptical orbits like the planets around the sun.
  - occupy a continuum of orbits but only radiate from some.
  - obey Maxwell's equations.
  - None of the above.

The remaining problems may require some computation. Choose the single best answer and enter your choice into the NCS-Scantron answer sheet.

97. A red ball is thrown straight down from the edge of a tall cliff with a speed of 15 m/s. At the same time a green ball is thrown straight up with the same speed. If the green ball travels up, stops, and then drops to the bottom of the cliff, how many seconds later than the red ball will it land?
- a. 3 s
  - b. 2.45 s
  - c. 4.9 s
  - d. 6 s
  - e. None of the above is within 10% of the correct answer.

98. To determine the height of a steep cliff an experimenter stations his assistant on the top of the cliff and fires a pellet vertically upward with a speed of 40 m/s. His assistant notes that the pellet reaches its maximum height just 3 m above the edge of the cliff. How high is the cliff?
- a). 77 m ; b). 237 m; c). 317 m; d). 637 m; e). 797 m.

99. A dirt bike starts up a steep hill with a speed of 5m/s, and speeds up at the rate of  $0.2\text{m/s}^2$  as it climbs the hill. It clears the crest of the hill after 15 seconds. How far did the dirt bike travel up the hill?
- a). 97.5 m; b). 75 m; c). 52.5 m; d) 15 m; e) none of these is correct within 10%.

100. A rope is used to drag a box across a rough warehouse floor. Its angle is 30 degrees above the horizontal, and the its tension is  $T$ . If the box has a mass of 15 kg, feels a frictional drag force of 57.4 N, and is accelerating horizontally at  $0.5 \text{ m/s}^2$ , what is the value of  $T$ , most nearly?  
a). 7.5N; b). 37.5 N; c) 75 N; d) 82.5 N; e) 95.3 N.
101. Just after it is launched from the moon rocket feels a gravitational attraction by the moon of about 6000 N. Compute the acceleration of the moon due to the force which Newton's third law guarantees that the satellite exerts on the earth. (Use  $M_M = 7 \times 10^{22} \text{ kg}$ ). The acceleration is most nearly  
a)  $10^{19} \text{ m/s}^2$ ; b)  $10^{20} \text{ m/s}^2$ ; c)  $10^{-20} \text{ m/s}^2$ ; d)  $10^{-19} \text{ m/s}^2$ ;  
e). None of these is correct within a factor of 10
102. Suppose that the moon travels in a circle about the earth at a distance of  $3.84 \times 10^8 \text{ m}$  once in every 28.3 days, and that has a mass of  $7.4 \times 10^{22} \text{ kg}$ . Then the speed of the moon is most nearly:  
a)  $10^3 \text{ m/s}$ ; b)  $10^4 \text{ m/s}$ ; c)  $10^8 \text{ m/s}$ ; d)  $10^{12} \text{ m/s}$ ; e) None of these is correct within a factor of 10.

103. The masses of the Sun and Earth are  $2 \times 10^{30}$  kg and  $6 \times 10^{24}$  kg, respectively. The Earth-Sun distance is  $1.5 \times 10^{11}$  m. What is the size of the gravitational force between Earth and the Moon most nearly? The gravitational constant is  $G = 6.67 \times 10^{-11}$  N·m<sup>2</sup>/kg<sup>2</sup>.

- a.  $3.6 \times 10^{11}$  N
- b.  $3.6 \times 10^{22}$  N
- c.  $3.6 \times 10^{43}$  N
- d.  $3.6 \times 10^{54}$  N
- e. None of the above is correct within a factor of 100.

104. A 90-kg satellite orbits a distant planet with a radius of 4000 km and a period of 280 min. From the radius and period, you calculate the satellite's acceleration to be  $8 \text{ m/s}^2$ . What is the gravitational force on the satellite?

- a. 50.4 N
- b. 90 N
- c. 720 N
- d. 12,000 N
- e. None of the above is within 10% of the correct value.

105. A 3-kg putty ball traveling to the right with a speed of 5 m/s overtook and collides with a 4-kg putty ball traveling in the same direction with a speed of 1 m/s. If the two balls stick together and move off as a single unit, what is the total kinetic energy after the collision, most nearly?

- a. 7 J
- b. 17 J
- c. 27 J
- d. 37 J
- e. 57 J

106. A 1200-kg ~~frictionless~~ roller coaster starts from rest at a height of 24 m. It travels 500 m under a frictional force of 144 N to the crest of a hill that is 12 m high. What is its kinetic energy at the top of the 12 m hill, most nearly?

- a. 288,000 J
- b. 216,000 J
- c. 72,000 J
- d. 14,400 J
- e. 0 J

107. An observer drops a ball in a train traveling along a straight, horizontal track with a constant acceleration of  $10 \text{ m/sec}^2$  in the forward direction. The observer is unaware of the acceleration but notices that the ball falls in a straight line that is slanted toward the back of the train. The acceleration of the ball along this line has a magnitude of \_\_\_\_\_  $\text{m/s}^2$ , most nearly.

- a.  $3.1 \text{ m/s}^2$ .
- b.  $10.0 \text{ m/s}^2$ .
- c.  $13.1 \text{ m/s}^2$ .
- d.  $14.1 \text{ m/s}^2$ .
- e. None of the above is within 10%<sup>^</sup> of the correct answer.

108. A cylindrical space habitat with a 1000-m radius is rotating so that a person standing on the inside feels a centripetal acceleration equal to  $g = 10 \text{ m/sec}^2$ . What is the tangential speed of a point just inside the cylinder?

- a. 5 m/s
- b. 20 m/s
- c. 63.2 m/s
- d. 100 m/s
- e. 200 m/s

109. 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
- 0.6 s
  - 0.8 s
  - 1.0 s
  - 1.25
  - 1.67 s
110. 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?
- 1.000 001
  - 1.000 01
  - 3.3
  - 4.67
  - 10
111. A hypothetical balloon filled with an ideal gas has a volume of  $10^5$  liters at  $27^\circ\text{C}$  under one atmosphere of pressure. At what temperature, most nearly, will its volume be  $10^4$  liters under one atmosphere of pressure?
- $-273^\circ\text{C}$
  - $-243^\circ\text{C}$
  - $-203^\circ\text{C}$
  - $-163^\circ\text{C}$
  - $-123^\circ\text{C}$

112. If 100 g of water at  $100^{\circ}\text{C}$  and 100 g of ice at  $0^{\circ}\text{C}$  are mixed with 100 g of water at  $50^{\circ}\text{C}$  in a completely insulated container, what is the final equilibrium temperature, most nearly? Recall that the latent heat of fusion of ice is  $80\text{ cal/g}$ .

- a.  $13^{\circ}\text{C}$
- b.  $23^{\circ}\text{C}$
- c.  $33^{\circ}\text{C}$
- d.  $43^{\circ}\text{C}$
- e. None of the above is within 20% of the correct answer.

113. An ideal heat engine has a theoretical efficiency of 47% and an exhaust temperature of  $127^{\circ}\text{C}$ . What is its input temperature, most nearly?

- a.  $230^{\circ}\text{C}$
- b.  $480^{\circ}\text{C}$
- c.  $600^{\circ}\text{C}$
- d.  $750^{\circ}\text{C}$
- e. None of the above is within 10% of the correct answer

114. An air-conditioner mechanic is testing a unit by running it on the workbench in an isolated room. The unit removes  $100\text{ cal/min}$  from the refrigerated chamber, utilizing a work input of  $420\text{ J/min}$ . By how much does the internal energy of the room outside the refrigerated chamber change, most nearly, in each minute?

- a. It decreases by  $100\text{ cal/min}$ .
- b. It decreases by  $200\text{ cal/min}$ .
- c. It decreases by  $520\text{ cal/min}$ .
- d. It stays the same.
- e. It increases by  $520\text{ cal/min}$ .
- f. It increases by  $200\text{ cal/min}$ .
- g. It increases by  $100\text{ cal/min}$ .

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115. A certain pendulum with a length of 2.0 m has a period of 2.8 s on earth. If the pendulum is moved to a planet where the gravitational force is twice as great as earth's, and its length is shortened to 1.0 m, what is its new period?
- 11.2 s
  - 5.6 s
  - 2.8 s
  - 1.4 s
  - 0.7 s
  - None of the above is correct within 10%.
116. The transverse wave speed along a string of length 0.4m fixed at both ends is 100 m/s. What is the frequency of the third harmonic on this string?
- 750 Hz
  - 375 Hz
  - 250 Hz
  - 125 Hz
  - None of the above is correct within 10%.
117. What is the de Broglie wavelength of a Volkswagen (mass = 1000 kg) traveling at 33.1 m/s (74 mph) most nearly? (Planck's constant is  $h = 6.63 \times 10^{-34}$  J·s.)
- $1.5 \times 10^{-29}$  m
  - $2.2 \times 10^{-39}$  m
  - $2.0 \times 10^{-38}$  m
  - $3.0 \times 10^{-28}$  m
  - None of the above is correct within 10%.

118. A microwave photon has an energy of  $6 \times 10^{-23}$  J. What is its wavelength, most nearly? (Planck's constant is  $h = 6.63 \times 10^{-34}$  J·s.)
- $1 \times 10^{-56}$  m
  - $3 \times 10^{-11}$  m
  - $10 \times 10^{-10}$  m
  - $3 \times 10^{-3}$  m
  - None of the above is correct within a factor of 10.
119. The energy levels of the Hydrogen atom are correctly given by the formula of the Bohr model; as follows,  $E_n = -13.6/n^2$  where  $n = 1, 2, 3, \dots$  gives the lowest orbits. (The energy units are electron Volts:  $1\text{eV} = 1.6 \times 10^{-19}$  J.) Calculate the energy emitted when an electron jumps from the third Bohr orbit to the first (lowest) orbit.
- 13.6 eV
  - 12.1 eV
  - 3.4 eV
  - 1.5 eV
  - None of the above is correct within 10%.
120. What most nearly is the frequency of the photon of energy 1.5 eV which might have been emitted in the electron jump of problem 119, just above? (Planck's constant is  $h = 6.63 \times 10^{-34}$  J·s, and  $1 \text{ (eV)} = 1.6 \times 10^{-19}$  J.)
- $4 \times 10^{13}$  Hz
  - $4 \times 10^{14}$  Hz
  - $4 \times 10^{15}$  Hz
  - $4 \times 10^{16}$  Hz
  - None of the above is correct within a factor of 10.