

1) Two He(lium) nuclei are a certain distance apart. One He nucleus is replaced by a C(arbon) nucleus, keeping the distance unchanged. What happens to the strength of the electrostatic force between the two nuclei?

- A) It increases by a factor of 3.
- B) It remains the same.
- C) It increases by a factor of 2.
- D) It decreases by a factor 4.
- E) It decreases by a factor of 3.

2) A 75-watt lightbulb

- A) creates 75 joules of radiant energy during every second.
- B) creates 75 joules of thermal energy during every second.
- C) creates a total of 75 joules of radiant energy during the bulb's entire lifetime.
- D) consumes a total of 75 joules of electric energy during the bulb's entire lifetime.
- E) consumes 75 joules of electric energy during every second.

3) Which of these energy transformations best describes the overall operation of a hydroelectric power plant?

- A) Thermal E \rightarrow Electric E
- B) Chemical E \rightarrow Electric E
- C) Gravitational E \rightarrow Thermal E
- D) Gravitational E \rightarrow Electric E
- E) Electric E \rightarrow Gravitational E

4) How long must a 100 W lightbulb run in order to use a million Joules of electric energy?

- A) About 1 hour.
- B) About 2 hours.
- C) About 50 minutes.
- D) About 2 hours and 47 minutes.
- E) About 1 hour and 34 minutes.

5) Satellite A orbits Earth at an altitude of 100 km, while satellite B (same mass as A) orbits at 200 km.

- A) A has greater gravitational energy and feels a greater gravitational force than B.
- B) A has less gravitational energy than B, but feels a greater gravitational force

- than B.
- C) A has less gravitational energy and feels a smaller gravitational force than B.
 - D) A has greater gravitational energy, but feels a smaller gravitational force than B.
 - E) None of the above.

6) A heat engine that consumes 800 J of thermal energy while exhausting 600 J has an efficiency of

- A) 75%.
- B) 25%.
- C) 20%.
- D) 10%.
- E) 40%.

7) You lift (at constant speed) a 20 kg box from the floor to a shelf 2.5 m above the floor. The work done by you on the book is

- A) 50 N.
- B) 200 J.
- C) 500 J.
- D) 50 J.
- E) 200 W.

8) If you do the lifting in the previous problem in 4 seconds, the power involved is

- A) 1 kW.
- B) 100 J.
- C) 2500 W.
- D) 125 W.
- E) None of the above.

9) In a steam-electric generating plant steam is heated to 327 degrees C. After passing through the turbine, the steam is cooled down to 27 degrees C. The best possible efficiency of this power plant is

- A) 25%.
- B) 50%.
- C) 35%.
- D) 43%.
- E) 40%.

10) In the plant of the previous question the input steam can only be heated to 250 degrees C, with everything else remaining the same. As a result, the best possible

efficiency

- A) would remain unchanged.
- B) would increase.
- C) would decrease.
- D) Depends on too many other factors.

11) A particular automobile operates at an overall efficiency of 10%. Suppose 20 gallons of gasoline are put into the tank. Of these 20 gallons, how much will be wasted, i.e. consumed to produce exhaust heat and in other ways that do not actually move the car down the road?

- A) 2 gallons.
- B) 18 gallons.
- C) 19 gallons.
- D) 10 gallons.
- E) 20 gallons.

12) A rolling object has a speed of 8 m/s as it approaches a 3 m high hill. Ignore rolling resistance and air resistance. Will the object make it over the top of the hill?

- A) No, not enough energy.
- B) Can't answer without knowing the object's mass.
- C) Yes, very easily, it will still have more than 50% of its initial speed when it reaches the top.
- D) Yes, but barely.

13) A car going 60 mi/hr has how much kinetic energy relative to the same car going 20 mi/hr?

- A) 9 times
- B) 3 times
- C) same amount
- D) depends on whether the car is going uphill or downhill
- E) half as much

14) Chemical energy is transformed into gravitational energy when

- A) a car accelerates on level ground.
- B) a leaf undergoes photosynthesis.
- C) a block slides downhill.
- D) a person walks uphill.
- E) a train slows down on level tracks.

15) The Coulomb force between an H^- ion and a carbon atom that had two electrons removed

- A) is attractive.
- B) is repulsive.
- C) is zero.
- D) can't be determined whether A) or B) or C) because we don't know their separation distance.

16) If a lightbulb has a resistance of 40 ohm and a current flowing through it of 2 amps, at what voltage is it operating?

- A) 80 V
- B) 40 V
- C) 20 V
- D) 110 V
- E) 220 V

17) You drive a purely electric car uphill. Including frictional forces (powertrain, tires, etc.) the basic overall energy transformation chain is

- A) $E_{\text{chemical}} \rightarrow E_{\text{kinetic}}$
- B) $E_{\text{electric}} \rightarrow E_{\text{thermal}} + E_{\text{kinetic}}$
- C) $E_{\text{chemical}} \rightarrow E_{\text{electric}} \rightarrow E_{\text{kinetic}} + E_{\text{thermal}}$
- D) $E_{\text{thermal}} \rightarrow E_{\text{electric}} \rightarrow E_{\text{gravitational}} + E_{\text{kinetic}}$
- E) $E_{\text{chemical}} \rightarrow E_{\text{electric}} \rightarrow E_{\text{thermal}} + E_{\text{kinetic}} + E_{\text{gravitational}}$

18) A heat engine produces 200 J of work and releases 800 J of thermal energy exhaust. Its efficiency is

- A) 20%.
- B) 40%.
- C) Not enough info given.
- D) 50%.
- E) 25%.

19) A 5 kg object is dropped from 1 m above the floor. Not neglecting air resistance, a few cm above the floor, its gravitational energy relative to the floor and its kinetic energy are (as always, take $g = 10 \text{ m/s}^2$)

- A) both zero.
- B) 50 J and zero.
- C) Almost zero and a bit less than 50 J.
- D) A bit over 50 J and almost zero.

E) Both are close to 50 J.

20) In a simple electric circuit consisting of battery & wire & a lamp you replace the wire with longer wire, leaving everything else unchanged. As a result

- A) the current in the circuit will decrease.
- B) the current will remain the same.
- C) the current will increase.
- D) the current will stop flowing.

21) A fundamental physics reason for the bicycle's high efficiency as a transportation device is:

- A) It is a wheeled vehicle and also an efficient heat engine.
- B) It uses the efficient human body.
- C) It is a wheeled vehicle and not a heat engine.
- D) It is a heat engine, but one that does not burn fossil fuels.
- E) Nonsense, trains and airplanes are actually more efficient than bicycles.

22) Once again ignore frictional forces. A 1000 kg roller coaster starts from rest down a 5 m high hill. Its speed at the bottom will be

- A) 5 m/s.
- B) 4 m/s.
- C) 10 m/s.
- D) 20 m/s.
- E) none of the above

23) Still ignoring frictional forces, the correct answer to 22) for a 500 kg roller coaster would be

- A) the same.
- B) different.
- C) Not enough info to answer.

24) It is in principle possible for two "harmonic" waves (the very regular waves in Figure 9.6) traveling in opposite directions to completely cancel each other, i.e. to effectively have no more remaining wave propagation.

- A) No.
- B) Yes.
- C) Such waves can interfere, but they can only enhance each other constructively.

25) If two electrons are near each other and are moving past each other, the electromagnetic forces they exert on each other will be

- A) electric (attractive) but not magnetic.
- B) electric (repulsive) but not magnetic.
- C) magnetic but not electric.
- D) both electric (attractive) and magnetic.
- E) both electric (repulsive) and magnetic.

26) Suppose in an ordinary hydrogen atom you replace each of the two particles (proton and electron) with their respective anti-particle, but make no other changes. Would the net Coulomb force change?

- A) No.
- B) Yes.
- C) Unclear because the charges of the anti-particles are unknown.
- D) There are no such anti-particles.

27) About how much CO₂ comes out of the stack of a coal-burning power plant that consumes one ton of coal?

- A) None, because the CO₂ is precipitated as a solid.
- B) Anywhere from 1 ton to 10 tons, depending on the plant's design.
- C) About 3.7 tons.
- D) About 2 tons.
- E) Considerably less than one ton.

28) An electric clothes dryer with a power consumption of 5000 W runs for ½ hour every 3rd day. At 10 cents per kW-hour how much will this cost you per month?

- A) About \$1.
- B) About \$5.
- C) About 50 cents.
- D) About \$1.50
- E) About \$2.50

29) Which of the following employs a heat engine?

- A) Gasoline-fueled car as well as diesel-fueled car.
- B) Wind generator.
- C) Hydro-electric power plant.

- D) Electric vehicle.
- E) None of the above.

30) A 100 W lightbulb running for one hour uses how much energy?

- A) 3.6 kJ
- B) 10^4 J
- C) 10^5 J
- D) 3.6×10^5 J
- E) 100 J

31) Waves A and B have the same wavespeed, but A's wavelength is longer. Which wave has the larger frequency?

- A) Wave A.
- B) Wave B.
- C) They have the same frequency.
- D) Need more info to answer, such as their amplitudes.

32) Two small sources of water waves send out circular waves, each with an amplitude of 2 cm. The water levels (relative to the undisturbed level) at the point where crest meets crest and where trough meets trough are, respectively,

- A) 4 cm and 0 cm.
- B) - 4 cm and 0 cm.
- C) 0 cm and 0 cm.
- D) 4 cm and - 4cm.
- E) 0 cm and 4 cm.

33) Which fundamental force holds the electrons in their atomic orbits?

- A) The gravitational force.
- B) The electromagnetic force.
- C) The strong nuclear force.
- D) Yet another force.

34) In the (annihilation) reaction $\text{proton} + \text{anti-proton} \rightarrow e^- + e^+$ (= positron, the electron's anti-particle)

- A) charge is conserved.
- B) charge is not conserved.
- C) Whether charge is conserved or not depends on the detailed motion of the various particles.
- D) charge conservation doesn't matter.

35) If you rub two transparencies with tissue and then hold them at rest a short distance apart, they will then exert

- A) no electric nor magnetic force on each other.
- B) a repulsive electric force on each other, but no magnetic force.
- C) an attractive electric force on each other, but no magnetic force.
- D) a repulsive magnetic force on each other, but no electric force.
- E) an attractive magnetic force on each other, but no electric force.

36) The magnetic forces exerted by a permanent magnet are due to

- A) electrons moving in atoms.
- B) large-scale (macroscopic) electric currents on the magnet's surface.
- C) equal and opposite electric charges placed on each of the two poles.
- D) equal and opposite magnets placed on each of the two poles.
- E) a miracle.

37) In the electric field of a Helium nucleus a stationary electron will

- A) feel no net force.
- B) feel a repulsive (relative to the nucleus) force.
- C) feel an attractive (relative to the nucleus) force.
- D) That nucleus doesn't set up an electric field.

38) In the operation of a typical, gasoline-fueled car, running unaccelerated and at a moderate highway speed, the thermal energy exhaust (i.e. radiator plus tailpipe)

- A) is comparable to the work done to actually run the car.
- B) is several times as large as the work done to actually run the car.
- C) is comparable to the sum of various frictional energy losses in engine, transmission, drive train and the energy needed to drive accessories such as water pump, AC, power steering, generator, etc.
- D) is less than the work done to actually run the car.

39) The energy content (energy per unit mass) of gasoline is

- A) similar to the energy content of the best modern batteries.
- B) within 2-3 orders of magnitude similar to the energy content of uranium.
- C) less than the energy content of food items such as cookies or butter.
- D) considerably higher than the energy content of the best batteries or even of the explosive TNT.
- E) irrelevant.

40) You have a lamp with fixed resistance, obeying Ohm's Law, and running at 110 V. When this voltage is doubled,

- A) the current through the lamp is halved.
- B) the current through the lamp remains the same.
- C) the current will go to zero.
- D) the current will also double.

Answers:

- 1. A
- 2. E
- 3. D
- 4. D
- 5. B
- 6. B
- 7. C
- 8. D
- 9. B
- 10. C
- 11. B
- 12. D
- 13. A
- 14. D
- 15. A
- 16. A
- 17. E
- 18. A
- 19. C
- 20. A
- 21. C
- 22. C
- 23. A
- 24. B
- 25. E
- 26. A
- 27. C
- 28. E
- 29. A
- 30. D
- 31. B
- 32. D
- 33. B
- 34. A
- 35. B
- 36. A
- 37. C

- 38. B
- 39. D
- 40. D