Name: _____

Multiple choice questions. 1 mark each.

1. A spaceship moves towards you at 1/3c, where c is the speed of light. The spaceship emits a beam of light in your direction. As measured in your frame of reference, the speed of the light emitted by the spaceship is:
   (a) 4/3c
   (b) c
   (c) 2/3c
   (d) 1/3c

2. A spaceship moves by you at a high speed. Compared to how they would appear to you if the spaceship were at rest, objects on the spaceship:
   (a) appear longer, and have greater mass
   (b) appear shorter, and have greater mass
   (c) appear longer and have smaller mass
   (d) appear shorter and have smaller mass

3. The predictions of Special Relativity appear to us to be counterintuitive because:
   (a) they only apply to the behaviour of microscopic particles, like electrons
   (b) they apply only to inanimate objects like clocks and rods, and not to human beings
   (c) they are only noticeable at speeds much higher than we normally experience
   (d) our intuition is based on experiences we have as infants, before we learn any physics

4. Which of the following is NOT a property of muons:
   (a) muons are unstable and decay into a different form of matter in a small fraction of a second
   (b) muons are created by cosmic rays in the upper atmosphere
   (c) muons travel at speeds very close to the speed of light
   (d) muons decay in the upper atmosphere and hardly ever make it to the Earth's surface

5. The resolution to the Twin Paradox lies in the observation that
   (a) no two people can be exactly the same age
   (b) the twin that stays on the Earth ages differently because of the Earth's gravitational field
   (c) the predictions of special relativity only apply to subatomic particles
   (d) one of the twins must accelerate in order to leave Earth and come back.

6. If tachyons were ever detected we would:
   (a) be able to move faster than the speed of light
   (b) be able to send messages back in time
   (c) be able to travel back in time
   (d) be able to travel forward in time

7. According to Newton's law of gravitation, if the distance between two masses is doubled, the gravitational force between them
   (a) decreases by a factor of two
   (b) decreases by a factor of four
   (c) increases by a factor of two
   (d) increases by a factor of four

8. As the altitude of a satellite in orbit around the Earth increases
   (a) its weight decreases and its mass stays the same.
   (b) its weight and mass decrease
   (c) its weight increases and its mass stays the same
   (d) its weight and mass stay the same.

9. If you double the mass of an object, the velocity that it needs to obtain in order to escape the gravitational pull of the Earth:
   (a) increases by a factor of two
   (b) decreases by a factor of two
   (c) increases by a factor of four
   (d) stays the same

10. Kepler's second law implies that a planet in an elliptic orbit around the sun:
   (a) moves fastest when it is furthest from the sun.
   (b) moves fastest when it is closest to the sun.
   (c) has an orbital period whose square is proportional to the cube of the semi-major axis of the orbit
   (d) will eventually lose its kinetic energy and spiral into the sun

11. Which of the following is **not** a flaw of Newton's gravity theory that was explained by Einstein's theory of relativity?
   (a) Newton's theory predicted the wrong perihelion shift for Mercury
   (b) Newton's theory was inconsistent with the special theory of relativity
   (c) Newton's theory did not explain why planets moved in elliptical orbits
   (d) Newton's theory did not explain why gravitational forces are proportional to inertial mass.

12. Which of the following is NOT a property of black holes?
   (a) They are essentially a region of space from which nothing, not even light can escape
   (b) Space around black holes is curved
   (c) At the center of a black hole is a singularity, where the laws of physics break down.
   (d) The space around a black hole is completely black, containing no radiation

13. Which of the following does NOT describe an electron in an atom?
    (a) An electron has a smaller mass than the nucleus.
    (b) The energy of the electron is fixed as long as it stays in a particular orbital.
    (c) An electron has a negative charge.
    (d) An electron continuously radiates light as it orbits the nucleus in a particular orbital.

14. One failure of a model of the atom based on the electron being considered as a particle is that the model predicts that
    (a) atoms will always be stable.
    (b) when heated, no light will be emitted from an atom.
    (c) atoms decay in a very short time.
    (d) when heated, only light of very low wavelengths is emitted.

15. Which of the following is NOT a characteristic of the Bohr model of the atom?
    (a) Electrons spontaneously jump from lower to higher energy levels, emitting photons.
    (b) Most of the mass of the atom is contained in the nucleus.
    (c) Electrons circle the nucleus in discrete orbits.
    (d) The Coulomb force between electrons and protons holds the atom together.

16. Which of the following is NOT a property of spontaneous emission?
    (a) It requires an incoming photon of precisely the right energy
    (b) Two photons of slightly different energies are emitted
    (c) It is the basis for the operation of lasers
    (d) During the emission process an electron goes from a higher to a lower energy level in the atom

17. The photoelectric effect
    (a) provides the basis for generating modern–day lasers.
    (b) can only be observed if photons of exactly the right frequency are used
    (c) demonstrates that light has a particle nature.
    (d) shows that electrons sometimes behave like waves

18. Electrons can clearly be seen to have a wave nature
    (a) under no circumstances.
    (b) in their behaviour in electrical circuits.
    (c) when used in diffraction experiments.
    (d) when colliding with other electrons in a wire.

19. According to the Heisenberg Uncertainty Principle, the uncertainty Δx in position of an object and uncertainty Δv in speed are related as $\Delta x\,\Delta v > h/4\pi m$, where m is the mass of the object and h is Planck's constant. This tells us that
    (a) knowing the exact position also tells us exactly the speed.
    (b) determining the position more accurately leads to a more accurate determination of the speed.
    (c) determining the position more accurately leads to a less accurate determination of the speed.
    (d) the accuracy of knowing the position is independent of the accuracy of knowing the speed.

20. An electron microscope can see finer structures than ordinary microscopes because
    (a) electrons are very tiny particles.
    (b) the energy of the electrons is relatively low.
    (c) the electrons have a relatively small de Broglie wavelength.
    (d) the electrons have a relatively large de Broglie wavelength.

21. Why don't ordinary objects like bowling balls readily exhibit a wave nature?
    (a) Only objects at the atomic scale in principle can behave as waves.
    (b) Bowling balls normally have an extremely short de Broglie wavelength.
    (c) Bowling balls normally have an extremely long de Broglie wavelength.
    (d) Bowling balls are usually electrically neutral.

22. A transistor as used in computers is best described as
    (a) a switch.
    (b) a good conductor.
    (c) an insulator.
    (d) a signal amplifier.

23. How many **bits** of information would be required to specify a number between 1 and 10
    (a) one
    (b) two
    (c) four
    (d) eight

24. In a p type semiconductor, current is said to be carried by
    (a) electrons or holes.
    (b) positrons.
    (c) electrons.
    (d) holes.

25. How many protons and neutrons are contained in an alpha particle?
    (a) 4 proton, 2 neutrons
    (b) 2 protons, 2 neutron
    (c) 2 protons, 4 neutron
    (d) 3 proton, 2 neutrons

26. Isotopes of an element differ by all but which of the following?
    (a) their relative abundance
    (b) the number of protons in the nucleus
    (c) the number of neutrons in the nucleus
    (d) their relative degree of radioactivity

27. Beta decay occurs by the emission of a beta particle and a neutrino. The role of the neutrino is to:
    (a) Carry away one unit of positive charge
    (b) Carry away one unit of negative charge
    (c) Carry away both momentum and energy
    (d) Carry away momentum only, but no energy, since it is massless

28. A 10 kg animal is exposed to 1 Gray of radiation. How much energy (in Joules) does the animal's body absorb during this process?
    (a) 0.1 Joule
    (b) 1 Joule
    (c) 10 Joules
    (d) 100 Joules

29. Which of the following is NOT a characteristic of a neutrino?
    (a) It generally is produced in beta–decay.
    (b) It is a massless particle, or at least nearly so.
    (c) It interacts readily with other particles.
    (d) It is a biologically harmless form of radiation.

30. Which of the following statements about radioactivity is true?
    (a) A high activity of a sample means it has a relatively long half life.
    (b) A high activity of a sample means it has a relatively short half life.
    (c) The activity of a sample does not necessarily indicate either a relatively long or short half life.
    (d) The activity and half life are both independent of the size of a sample.

31. Which of the following medical diagnostic techniques is generally considered the least risk from radiation exposure?
    (a) a chest X–ray
    (b) a CAT (computer aided tomography) scan
    (c) a PET (positron emission tomography) scan
    (d) an MRI (magnetic resonance imaging) scan

32. What is the largest single source of radiation exposure for an average North American?
    (a) radon gas
    (b) nuclear power plants
    (c) cosmic rays
    (d) naturally occurring uranium

33. How much of a radioactive substance remains after a period of two half lifes?
    (a) one half
    (b) one quarter
    (c) one eighth
    (d) it depends on how much there was to begin with

34. One difference between nuclear fission and fusion is that
    (a) fission splits apart nuclei, while fusion combines nuclei.
    (b) only fission occurs in the Sun.
    (c) only fission has been used in atomic weapons.
    (d) only fusion involves the conversion of mass into energy.

35. Advantages of nuclear fusion over fission in the generation of power include all but which of the following?
    (a) Fusion generally leads to no radioactive waste.
    (b) There is an abundance of fuel that could be used in fusion reactors.
    (c) It is currently much cheaper to employ fusion in a nuclear reactor.
    (d) There is no danger of a "meltdown" in a fusion reactor.

36. Compared to its matter twin, antimatter
    (a) has the same mass but opposite electric charge.
    (b) has a different mass but the same electric charge.
    (c) has a different mass and opposite electric charge.
    (d) has the same mass and the same electric charge.

37. According to the Nebular Hypothesis, the solar system began as
    (a) a rapidly rotating sun.
    (b) a cloud containing mostly heavy elements.
    (c) a cloud of dust and gas.
    (d) the result of a collision between two giant suns.

38. The terrestrial planets are
    (a) Mercury, Venus, Earth, and Mars.
    (b) Jupiter, Saturn, Uranus, and Neptune.
    (c) Jupiter, Saturn, Uranus, Neptune, and Pluto.
    (d) Venus, Earth, and Mars.

39. The four layers of the Earth, going from the center to the surface, are the
    (a) inner core, outer core, mantle, and crust.
    (b) outer core, inner core, mantle, and crust.
    (c) inner core, outer core, crust, and mantle.
    (d) inner core, mantle, outer core, and crust.

40. The layers of the Earth were formed
    (a) just after the Great Bombardment.
    (b) in the planetary nebula phase.
    (c) during the Great Bombardment.
    (d) during the initial formation of the Earth.

41. The motion of tectonic plates is responsible for all but which of the following?
    (a) continental drift
    (b) ocean currents
    (c) earthquakes
    (d) mountain formation

42. The movement of tectonic plates is believed to be caused by
    (a) conduction currents originating in the Earth's core.
    (b) convection currents originating in the Earth's core.
    (c) the mantle being composed mostly of molten rock.
    (d) the rotation of the Earth about its axis.

43. Volcanos are common
    (a) along divergent plate boundaries.
    (b) along transform plate boundaries.
    (c) near the middle of a plate.
    (d) in none of the above situations.

44. What powers the global atmospheric circulation?
    (a) ocean currents
    (b) energy from the Sun
    (c) geothermal energy
    (d) cosmic rays

45. Doppler radar, as used in weather forecasting, can measure
    (a) the location and velocity of weather systems.
    (b) only the location of weather systems.
    (c) only the velocity of weather systems.
    (d) none of the above.

46. Place the three main classes of rocks in the most likely order of average age (from youngest to oldest):
    (a) igneous, metamorphic, sedentary
    (b) sedentary, igneous, metamorphic
    (c) sedentary, metamorphic, igneous
    (d) metamorphic, sedentary, igneous

47. The banning of CFCs (chlorofluorocarbons) will help in solving problems associated with
    (a) the ozone hole.
    (b) the greenhouse effect.
    (c) acid rain.
    (d) the ozone hole and the greenhouse effect.

48. What natural effect may compensate for global warming due to the greenhouse effect?
    (a) Increased heat will burn away clouds, leading to increased release of heat into space.
    (b) Increased heat will lead to more cloud formation, preventing more solar heat from reaching the earth.
    (c) The radiation entering the earth will be more ultraviolet in nature, which has less of a heating effect.
    (d) The increased radiation will destroy more of the ozone layer, allowing more heat to escape the earth.

49. What is believed will be the final stage of our Sun's life?
    (a) red giant
    (b) white dwarf
    (c) neutron star
    (d) pulsar

50. The three main ultimate fates of a given star are either
    (a) red giant, white dwarf, or neutron star.
    (b) white dwarf, black hole, or quasar.
    (c) neutron star, black hole, or white dwarf.
    (d) red giant, white dwarf, or black hole.

51. The force that prevents the total gravitational collapse of a white dwarf is that due to
    (a) neutrons obeying the Pauli exclusion principle.
    (b) electrons obeying the Pauli exclusion principle.
    (c) the heat generated by fusion reactions in the core.
    (d) the incompressibility of heavy elements in the core.

52. The force that prevents the total gravitational collapse of a neutron star is that due to
    (a) neutrons obeying the Pauli exclusion principle.
    (b) electrons obeying the Pauli exclusion principle.
    (c) the heat generated by fusion reactions in the core.
    (d) the incompressibility of heavy elements in the core.

53. The property of a star that mainly determines its ultimate fate is:
    (a) Its luminosity
    (b) Its age when it runs out of fuel
    (c) Its mass
    (d) The ratio of its number of electrons to number of neutrons

54. Red giants can be described as
    (a) huge planets with glowing hot surfaces.
    (b) stars in the hydrogen burning phase of their lives.
    (c) large stars that emit relatively little energy but have a relatively high surface temperature.
    (d) large stars that emit a relatively large amount of energy but have a relatively low surface temperature.

55. Which of the following is NOT true about neutron stars?
    (a) They are relatively large stars.
    (b) They spin rapidly.
    (c) In their formation they can be associated with supernovas.
    (d) They sometimes become pulsars.

56. Which of the following lists the events in an average star's life in the correct chronological order, from earliest to last?
    (a) helium burning phase, hydrogen burning phase, nebular collapse
    (b) nebular collapse, hydrogen burning phase, helium burning phase
    (c) hydrogen burning phase, helium burning phase, nebular collapse
    (d) hydrogen burning phase, nebular collapse, helium burning phase

57. The heavier elements found on planets are thought mainly to have come from
    (a) explosions of black holes.
    (b) fusion reactions at the core of the planets.
    (c) rapidly rotating pulsars emitting matter.
    (d) supernova explosions.

58. Quasars are
    (a) rapidly rotating neutron stars.
    (b) a large collection of stars in a rather static configuration.
    (c) the end result of the collapse of a certain type of star.
    (d) a large collection of stars which emits vast amounts of energy.

59. Which of the following is considered as supporting evidence for the Big Bang Theory of the Universe:
    (a) It predicts the presence of cosmic microwave background radiation with a temperature of 2.7 Kelvin
    (b) It predicts accurately the observed distribution of stars in our galaxy
    (c) It predicts accurately the relative abundance of heavy elements (such as iron) to light elements (such as helium)
    (d) It predicts the existence of Dark Matter in the universe

60. Which of the following is NOT associated with Hubble's law?
    (a) The further away a galaxy is, the faster it is moving away from us.
    (b) The spectrum of light from galaxies is Doppler shifted towards the red.
    (c) Galaxies are grouped into clusters.
    (d) The universe appears to be expanding.

PART II : Short Answer Questions. 3 Marks Each Part.

1. Explain **briefly** how Einstein arrived at the postulate that "the speed of light is the same for all observers in uniform motion".

2. The special theory of relativity provides both good news and bad news for the human race's prospects for interstellar space travel. Explain **briefly**

3. Describe two phenomena that show light behaves like particles.

4. Describe the purpose of any three devices which use semiconducting materials.

5. What are three practical applications which involve radioactive materials, other than in nuclear weapons?

6. Describe three common uses of lasers in our lives today.

7. Describe three non-medical uses of radiation

8. What are two major problems associated with present day nuclear power plants?

9. Describe briefly the currently accepted theory of the origin of the Solar System.

10. What are the three main ways that plates of the Earth can meet?

11. There are three main cycles of the Earth. Give an example where something in one cycle affects another cycle.

12. What is the greenhouse effect?

13. What does ozone in the upper atmosphere do, and why is it important to us?

14. Describe the two main stages that our Sun will go through as it burns out.

15. What is believed to be the origin of the heavier elements on the Earth?

16. What are the two possible fates of the Universe in the Big Bang model? What is the main factor that will determine which of the two will ultimately occur?

Have a good summer!