INSTRUCTIONS: **Please, use the `bubble sheet' and a pencil # 2 to answer the exam questions,** by marking the appropriate bubble for each question.
Write your last and first name and Student ID on the `bubble sheet', and mark them in the bubbles. Use of textbook and class notes is allowed. **There are a total of 49 questions.**

1. The principal difference between X-rays and visible light is:
   A. X-rays carry more energy per photon
   B. Blackbodies cannot produce X-rays
   C. Only visible light can travel through vacuum
   D. X-rays travel at the speed of sound
   E. X-rays have longer wavelength than visible light

2. At what temperature does an object produce thermal radiation?
   A. Above 0 degrees F
   B. Above 0 degrees C
   C. Above 0 degrees K
   D. Above 100 degrees C (212 degrees F)
   E. Above 2200 degrees C (4000 degrees F)

3. Radiant energy is:
   A. the energy from a nuclear power plant
   B. the energy transmitted by radio stations
   C. the energy carried by electromagnetic waves
   D. the energy used in home radiators
   E. heat energy

4. The _____ of a gas is a measure of the average speed of its particles.
   A. heat
   B. composition
   C. blue shift
   D. binding energy
   E. temperature

5. Electromagnetic radiation is emitted or absorbed when
   A. electrons are attracted by gravity.
   B. atoms are heated.
   C. atoms are cooled.
   D. electrons are accelerated or decelerated.
   E. all of the above.

6. Absolute zero is
   A. zero degrees Celsius
   B. zero degrees Fahrenheit
   C. the temperature at which water freezes
   D. the temperature at which atoms have no thermal energy
   E. both A and C

7. A photon produced in the center of the Sun takes _____ to reach the surface.
   A. 8.3 minutes
   B. 1,000 minutes
   C. 1,000 years
   D. 100,000 years
   E. 10,000,000 years

8. Blackbody radiation is:
   A. continuous
   B. due to the thermal motion of electrons, which emit photons
   C. confined to a few specific wavelengths, depending on the material
   D. invisible to the naked eye
   E. A and B

9. You see two bright stars in the night sky. One looks clearly red, the other clearly blue. Which one has the higher temperature?
   A. The color does not provide information on the temperature
   B. The brighter star
   C. The red star
   D. The blue star
   E. They have the same temperature.

10. If you want to determine the temperature of a star, you look at:
    A. its luminosity
    B. its color
    C. its radius
    D. its distance
    E. A and B

11. The Sun has a surface temperature of approximately 5,800 K. The maximum of the energy it radiates occurs at a wavelength of:
    A. 10 nm
    B. 100 nm
    C. 500 nm
    D. 3000 nm
    E. 5000 nm

12. You are comparing two optical telescopes. The second one has a diameter than is three times the diameter of the first telescope. From that you conclude:
   A. The second telescope has three times the collecting area and three times better (smaller value of the) angular resolution than the first telescope
   B. The second telescope has three times the collecting area and three times worse (larger value of the) angular resolution than the first telescope
   C. The second telescope has nine times the collecting area and three times better (smaller value of the) angular resolution than the first telescope
   D. The second telescope has nine times the collecting area and three times worse (larger value of the) angular resolution than the first telescope
   E. The second telescope has nine times the collecting area and nine times better (smaller value of the) angular resolution than the first telescope

13. If the temperature of an object doubles, the total amount of energy it emits will be
   A. the same
   B. two times larger
   C. four times larger
   D. eight times larger
   E. sixteen times larger

14. Star A and Star B are identical, but Star A is 5 times further away from Earth than Star B. Thus Star A will appear:
   A. 25 times fainter than Star B
   B. 5 times fainter than Star B
   C. about the same brightness as Star B
   D. 5 times brighter than Star B
   E. 25 times brighter than Star B

15. What is the most abundant element in the Universe and the Sun?
   A. Helium
   B. Hydrogen
   C. Neon
   D. Iron
   E. Calcium

16. Two rocks have been, separately, heated in an oven to high temperatures, and they emit nearly perfect theoretical blackbody radiation. One is red and very luminous, the other is bluer and very faint. Which one has the larger radius?
   A. The blue one, because `bluer' means larger radius.
   B. The blue one, because `very faint' means larger radius.
   C. The red one, because `very luminous' means larger radius.
   D. They have about the same radius, because redder color and higher luminosity compensate each other.
   E. We cannot say anything about size from luminosity and color

17. If the size of an object doubles, but its temperature stays the same, the total amount of energy it emits will be
A. the same
B. two times larger
C. four times larger
D. eight times larger
E. sixteen times larger

18. Atoms of different elements have unique spectral lines because each element
A. has unique photons
B. has a unique set of temperatures
C. has atoms of a unique color
D. has a unique set of electron orbits
E. has a unique set of neutrons

19. The number of electrons lost by an atom in a gas (that is, it's ionization state) depends primarily on
A. the velocity of the gas
B. the Doppler Shift of the gas
C. the level of the ground state
D. the size of the gas cloud
E. the temperature of the gas

20. Two otherwise identical stars are rotating at different rates. Star A is rotating faster than Star B. How do Star A's spectral lines appear with respect to Star B's lines?
A. Star A's lines are narrower than Star B's lines.
B. Star B's lines are narrower than Star A's lines.
C. There is no difference in the lines of the two stars.
D. Star A's lines are stronger than Star B's lines.
E. Star B's lines are stronger than Star A's lines.

21. A space telescope has an advantage over ground-based telescopes because:
A. It can be built to be much larger than a ground-based telescope
B. It is closer to the objects it is observing
C. It can observe optical light
D. It can observe light normally absorbed by the atmosphere (Ultraviolet, X-ray)
E. All of the above

22. A photons interacting with an atom produces the following change in the atom:
A. the atom loses a proton
B. the nucleus begins to glow
C. the atomic number increases
D. the photon becomes trapped in an orbit
E. an electron changes orbital

23. A star is receding from the Earth, and its emission lines (that are at ultraviolet wavelengths in the rest frame) are observed to be at visible wavelengths, or about twice the wavelength at rest. Thus the observed energy per photon is:
A. four times the energy of the emitted photon
B. twice the energy of the emitted photon
C. the same energy as the emitted photon
D. half the energy of the emitted photon
E. one fourth the energy of the emitted photon

24. The fusion of four hydrogen nuclei into a helium nucleus releases energy because
A. fusion only occurs at high temperatures
B. a helium nucleus has two protons, hydrogen has only one
C. a helium nucleus weighs less than four hydrogen nuclei
D. fusion can only occur in the centers of stars
E. helium is made of antimatter

25. Sunspots are dark because
A. they are so hot that they emit most of their energy in gamma rays
B. locally heavy solar winds blow out the solar flame
C. they contain so much heavy material that light cannot escape
D. they have lower temperature than surrounding regions
E. magnetic fields bring up iron from the core, which block the light

26. If a star has half the temperature of our Sun, but has the same luminosity, how large is its radius compared to the Sun?
A. half the radius of the Sun
B. one quarter the radius of the Sun
C. the same radius as the Sun
D. twice the radius of the Sun
E. four times the radius of the Sun

27. Which of the following statements best describes the Einstein's relation $E=mc^2$?
A. Energy is a finite resource
B. If we accelerate a mass to reach the speed of light, we create excess energy
C. Energy and mass can be converted into each other
D. The amount of energy goes up when we make light go faster
E. The energy of an object depends on its speed

28. The granulation on the surface of the Sun is caused by:
A. Convective gas rising from below the photosphere
B. Sunspots
C. Shock waves in the corona
D. The solar wind flowing away from the corona
E. The heating in the chromosphere

29. Most of the light we see from the Sun originates from:
    A. the corona
    B. the chromosphere
    C. the sunspots
    D. the magnetic field
    E. the photosphere

30. The bulk of the violent surface activity we observe on the Sun is due to seasonal variations in the Sun's
    A. Radius
    B. Temperature
    C. Energy Output
    D. Magnetic field
    E. Electric field

31. The differential rotation of the Sun
    A. causes the heating of the chromosphere and corona, which makes them hotter than the photosphere
    B. implies that the equatorial regions of the Sun rotate faster than the polar regions
    C. is caused by the magnetic dynamo inside the Sun
    D. causes the sunspots to slowly migrate from the equator towards the Sun poles
    E. implies that the Sun's Northern and Southern Hemispheres rotare in opposite directions

32. A 50-watt light bulb is 25 times more luminous than a 2-watt light bulb. The two will appear equally bright if:
    A. the 50-watt light bulb is located 125 times further away than the 2-watt light bulb
    B. the 50-watt light bulb is located 25 times further away than the 2-watt light bulb
    C. the 50-watt light bulb is located 5 times further away than the 2-watt light bulb
    D. the 2-watt light bulb is located 5 times further away than the 50-watt light bulb
    E. the 2-watt light bulb is located 25 times further away than the 50-watt light bulb

33. The Sun's corona is hotter than the photosphere because of
    A. extra heat received from the Sun's prominences
    B. the `whipping' motion of the Sun's magnetic lines
    C. the `whipping' motion of the Sun's flares
    D. the heating from the solar wind
    E. extra heat carried by convection cells from the solar interior

34. The fusion of hydrogen into helium needs high temperature because
    A. of the high value of the ground state energy of the hydrogen atom
    B. of the presence of other helium nuclei
    C. of the need for low density
    D. the protons need to overcome the Coulomb barrier
    E. neutrinos carry away more energy than the reaction produces

35. The temperature at the center of the Sun is approximately
    A. 6,000 K
    B. 20,000 K
    C. 500,000 K
    D. 1,500,00 K
    E. 15,000,000 K

36. The Sun's layer just outside the core is the
    A. chromosphere
    B. convection zone
    C. radiative zone
    D. photosphere
    E. corona

37. The granulation on the surface of the Sun is an indication that
    A. neutrinos are emitted by the Sun
    B. sunspots are colder regions than their surroundings
    C. the Sun's corona is hot
    D. energy is transported out of the Sun by radiation
    E. energy is transported out of the Sun by convection

38. The solar cycle, i.e., the length of time between numerous sunspots, is
    A. 29 days
    B. 1 year
    C. 11 years
    D. 121 years
    E. 22 years

39. The Sun's luminosity comes primarily from
    A. chemical burning
    B. gravitational contraction
    C. the mechanical energy of turbulence
    D. nuclear fusion
    E. B and D

40. Every second, the Sun converts 600 million tons of hydrogen into 596 million
     tons of heliun. The remaining 4 million tons
     A. is destroyed
     B. is ejected in space by solar flares
     C. is used to fuel additional nuclear fusions
     D. is ejected into space in a coronal mass ejection
     E. is emitted in the form of radiation

41. Two identical stars are observed from the Earth. Star A's emission lines (that are
     at ultraviolet wavelengths in the rest frame) are observed to be at visible
     wavelengths. The same emission lines for Star B are observed to be at infrared
     wavelengths. From these observations you conclude that:
     A. Star A is moving towards the Earth faster than Star B
     B. Star B is moving towards the Earth faster than Star A
     C. Both stars are moving away from the Earth at the same speed
     D. Star B is moving away the Earth faster than Star A
     E. Star A is moving away the Earth faster than Star B

42. The energy emitted by the Sun is produced
     A. in a small region at the center of the Sun
     B. uniformly throughout the Sun
     C. mainly in the center, but also in external regions according to a inverse square
     law
     D. from radioactive elements created during the Big Bang
     E. mainly in a region slightly outside the geometrical center

43. Suppose you could magically inject, all at once, a large amount of
    energy into the core of the Sun. What would happen?
    A. The Sun would contract as the core heated up.
    B. The Sun would contract as the energy became gravitational potential energy
    and find new equilibrium with the thermal pressure. The Sun would end up being
    smaller in size.
    C. The injected energy would heat the core, causing the Sun to expand. The Sun
    would find a new equilibrium with the gravitational pressure and end up being
    larger in size.
    D. The injected energy would heat the core, causing the Sun to expand. The
    energy would eventually be radiated off into space and the Sun would return to
    normal size.

44. What keeps the Sun from collapsing under its own gravity?
     A. The intense magnetic fields in its core
     B. The outward force exerted by the pressure of the hot gas in its interior
     C. The fact that its interior is mostly iron, giving it great strength
     D. The fact that its gaseous interior is incompressible
     E. The fact that its interior is a hot liquid and cannot be compressed.

45. A planet is located 4 times further away from the Sun than the Earth. From the planet's surface, the Sun appears:
   A. 16 times fainter than from the Earth
   B. 4 times fainter than from the Earth
   C. 2 times fainter than from the Earth
   D. about the same brightness as on the Earth
   E. 4 times brighter than from the Earth

46. The best model to describe the physical structure of an atom is:
   A. protons orbiting a nucleus of electrons and neutrons
   B. electrons orbiting a nucleus of protons and neutrons
   C. electrons and protons orbiting a nucleus of neutrons
   D. electrons, protons, and neutrons orbiting around each other in a cloud
   E. electrons and positrons orbiting a mini-black-hole.

47. The force that keeps electrons in orbit around the nucleus of an atom is due to:
   A. the intense gravity of the dense nucleus
   B. the attraction of opposite electrical charges
   C. its orbital velocity
   D. the magnetic field of the nucleus

48. How much electrical charge does an atom with 6 protons, 6 neutrons, and 5 electrons have?
   A. a total negative charge of -1
   B. a total negative charge of -2
   C. a total positive charge of +2
   D. a total positive charge of +1

49. When an atom loses an electron, it becomes:
   A. an ion
   B. an isotope
   C. a lighter element
   D. an heavier element
   E. dissociated

Solutions:
1. A
2. C
3. C
4. E
5. D
6. D
7. D
8. E
9. D
10. B
11. C
12. C
13. E
14. A
15. B
16. C
17. C
18. D
19. E
20. B
21. D
22. E
23. D
24. C
25. D
26. E
27. C
28. A
29. E
30. D
31. B
32. C
33. B
34. D
35. E
36. C
37. E
38. C
39. E
40. E
41. D
42. A
43. D
44. B
45. A

46. B
47. B
48. D
49. A