Astrophysical Algebra

Algebra · Answer Key · 24 Questions

1. If the orbital period T of a planet in years is given by T = a^(3/2) where 'a' is the semi-major axis in AU, what is the semi-major axis of a planet with an orbital period of 64 years?

A) 4 AU
B) 8 AU
C) 16 AU
D) 32 AU

2. The luminosity L of a star is proportional to the square of its radius R and the fourth power of its temperature T (L ? R²T4). If a star's radius is doubled and temperature halved, by what factor does its luminosity change?

A) 0.5
B) 1
C) 2
D) 4

3. The escape velocity v from a planet is given by v = sqrt(2GM/r). If mass M is increased by 8 and radius r by 2, by what factor does the escape velocity increase?

A) 1
B) 2
C) 4
D) 8

4. Using the equation d = vt, where d is distance and v is velocity, calculate the distance in km to a star if light (300,000 km/s) takes 5 years to reach Earth (Assume 1 year = 31,536,000 seconds).

A) 4.73 x 10^13 km
B) 9.46 x 10^13 km
C) 1.42 x 10^14 km
D) 2.84 x 10^14 km

5. The magnitude system for star brightness uses the formula m1 - m2 = -2.5 * log10(F1/F2). If the flux ratio F1/F2 is 100, what is the difference in magnitude?

A) 1
B) 2.5
C) 5
D) 10

6. A satellite orbits at a radius r. The centripetal acceleration is $a = v^2/r$. If velocity v is tripled and radius r is doubled, what is the new acceleration factor?

A) 1.5
B) 4.5
C) 6
D) 9

7. The gravitational force F between two bodies is $F = G(m1*m2)/r^2$. If the distance r between Earth and the Moon were halved, how would the gravitational force change?

A) Halved
B) Doubled
C) Quartered
D) Quadrupled

8. The Drake Equation estimates N = R*fp*ne*fl*fi*fc*L. If all variables are constants except L (the lifetime of a civilization), and L increases by a factor of 10, how does N change?

A) Remains same
B) Increases by 10
C) Increases by 100
D) Decreases by 10

9. Hubble's Law states v = H0 * d. If H0 is 70 km/s/Mpc, at what distance in Mpc is a galaxy moving away at 7,000 km/s?

A) 10 Mpc
B) 50 Mpc
C) 100 Mpc
D) 700 Mpc

10. The surface area of a spherical planet is $4?r^2$. If the radius of Mars is approximately 3,390 km, what is the expression for its surface area?

A) 11,492,100? km²
B) 45,968,400? km²
C) 12,852,100? km²
D) 38,556,300? km²

11. The redshift z is defined by 1+z = ?obs / ?emit. If a galaxy has a spectral line observed at 600nm that was emitted at 400nm, what is the redshift z?

A) 0.25
B) 0.5
C) 0.75
D) 1.5

12. For an object in circular orbit, orbital velocity v = sqrt(GM/r). If a planet moves to a new orbit where the radius is 4 times larger, what is the factor of change in orbital velocity?

A) 0.25
B) 0.5
C) 2
D) 4

13. The mass-luminosity relation for main sequence stars is L ? M^3.5. If a star is 4 times as massive as the Sun, how many times more luminous is it?

A) 14
B) 32
C) 64
D) 128

14. A rocket's mass ratio is R = mi/mf. Using the Tsiolkovsky rocket equation ?v = ve * ln(R), if ?v = 2*ve, what is the mass ratio R?

A) e
B) e^2
C) 2e
D) ln(2)

15. The Stefan-Boltzmann law states P = A?T4. If the temperature of a blackbody increases from 2,000K to 4,000K, by what factor does the power output increase?

A) 2
B) 4
C) 8
D) 16

16. The orbital angular momentum L = mvr. If a satellite's mass is doubled, its velocity is halved, and its distance from the planet is tripled, what is the new angular momentum?

A) 1.5 times the original
B) 2 times the original
C) 3 times the original
D) 4.5 times the original

17. Kepler's Second Law implies that for a planet in an elliptical orbit, the product of velocity and distance at perihelion equals the product at aphelion (v1*r1 = v2*r2). If r1=1AU and r2=3AU, what is the ratio v1/v2?

A) 1:3
B) 3:1
C) 1:9
D) 9:1

18. The density of a spherical planet is ? = M / (4/3 * ? * r^3). If the radius of a planet is doubled while mass remains constant, what is the factor of change in density?

A) 0.125
B) 0.25
C) 0.5
D) 4

19. If the Sun's mass is 1.989 x 10^30 kg and Earth's mass is 5.97 x 10^24 kg, what is the approximate ratio of the Sun's mass to Earth's mass?

A) 3.33 x 10^5
B) 3.33 x 10^4
C) 3.33 x 10^6
D) 3.33 x 10^3

20. The Schwarzschild radius Rs of a black hole is 2GM/c^2. If the mass M of a black hole is doubled, what is the factor of change in the Schwarzschild radius?

A) 0.5
B) 2
C) 4
D) 8

21. The energy E of a photon is E = hc/?. If the wavelength ? is cut in half, what happens to the energy E?

A) Divided by 2
B) Multiplied by 2
C) Multiplied by 4
D) Remains same

22. A light-year is the distance light travels in a year. Given c = 3 x 10^8 m/s, approximately how many meters is one light-year?

A) 9.46 x 10^15 m
B) 3 x 10^12 m
C) 3.15 x 10^7 m
D) 9.46 x 10^12 m

23. If the period of a pulsar is 0.033 seconds, what is its frequency in Hertz (f = 1/T)?

A) 3.03 Hz
B) 10.3 Hz
C) 30.3 Hz
D) 303 Hz

24. The flux of light from a star follows the inverse square law F = L / (4?d²). If the distance d is increased by 10, how does the flux F change?

A) Decreases by 10
B) Decreases by 100
C) Increases by 10
D) Increases by 100