GLOBAL ASTRONOMY & ASTROPHYSICS CHALLENGE

MOCK TEST

Practice Examination

40 Multiple-Choice Questions with Full Solutions

TOPICS COVERED

Observational Astronomy · Astrophysics · Planetology
Cosmology · Orbital Mechanics · Space Missions

2026

Test Bank Questions

Physical and Astronomical Constants (Reference)

- Speed of light $c = 3.0 \times 10^8$ m/s
- Gravitational constant $G = 6.674 \times 10^{-11}$ m^3 kg^{-1} s^{-2}
- Solar mass $M_\odot = 1.989 \times 10^{30}$ kg
- Solar radius $R_\odot = 6.96 \times 10^8$ m
- Astronomical unit 1 AU $= 1.496 \times 10^{11}$ m $= 1.5 \times 10^8$ km
- Parsec 1 pc $= 2.06 \times 10^5$ AU
- Arcseconds per radian 206 265
- Photon energy $hc = 1240$ eV·nm
- Earth's gravitational parameter $\mu_\oplus = 398\,600$ km^3/s^2
- Earth's mean radius $R_\oplus = 6371$ km
- Hubble constant $H_0 = 70$ km/s/Mpc
- Sun's main-sequence lifetime 10 Gyr

Q1

An 8-metre telescope and a 2-metre telescope observe the same faint galaxy. How many times more light does the larger telescope collect per second?

(A) 2 times
(B) 4 times
(C) 16 times
(D) 64 times

Answer: (C) **Difficulty:** Easy

Solution: Collecting area scales as D^2:

$$\frac{A_1}{A_2} = \left(\frac{D_1}{D_2}\right)^2 = \left(\frac{8}{2}\right)^2 = 16 \tag{1}$$

Q2

Star A has apparent magnitude $m_A = 8$ and Star B has $m_B = 13$. How many times brighter does Star A appear?

(A) 5 times
(B) 25 times
(C) 100 times
(D) 500 times

Answer: (C) **Difficulty:** Easy

Solution:

$$\frac{F_A}{F_B} = 10^{0.4(m_B - m_A)} = 10^{0.4\times 5} = 10^2 = 100 \tag{2}$$

Q3

A 5-metre telescope observes at a wavelength of $\lambda = 500$ nm. What is its diffraction-limited angular resolution in arcseconds (given by Rayleigh's criterion)?

(A) 0.005 arcsec

(B) 0.01 arcsec

(C) 0.025 arcsec

(D) 0.06 arcsec

Answer: (C) **Difficulty:** Medium

Solution: Rayleigh's criterion gives $\theta = 1.22\,\lambda/D$:

$$\theta = 1.22\,\frac{\lambda}{D} = 1.22 \times \frac{500 \times 10^{-9}}{5} = 1.22 \times 10^{-7}\ \text{rad} \tag{3}$$

Converting: $\theta = 1.22 \times 10^{-7} \times 206\,265 \approx 0.025$ arcsec.

Q4

At what zenith angle does the atmospheric air mass equal 2.0?

(A) $0°$

(B) $30°$

(C) $60°$

(D) $90°$

Answer: (C) **Difficulty:** Medium

Solution: For a plane-parallel atmosphere, air mass $X \approx \sec z$:

$$X = \frac{1}{\cos z} = 2 \implies \cos z = 0.5 \implies z = 60° \tag{4}$$

Q5

Which spectral type has the highest effective surface temperature?

(A) F5V

(B) K2V

(C) M5V

(D) G2V

Answer: (A) **Difficulty:** Easy

Solution: The spectral sequence from hottest to coolest is O, B, A, F, G, K, M. Among the choices, F5V is the hottest.

Q6

Star X has $B-V = 0.30$ (blue) and Star Y has $B-V = 1.20$ (red). Which statement is correct?

(A) Star X is cooler than Star Y

(B) Star Y is hotter than Star X

(C) Star X is hotter than Star Y

(D) Both stars have the same temperature

Answer: (C) **Difficulty:** Easy

Solution: A smaller (more negative) $B-V$ colour index indicates a hotter star. Star X with $B-V = 0.30$ is significantly hotter than Star Y with $B-V = 1.20$.

Q7

A telescope has a primary mirror focal length of $f = 8.0$ m. What is its plate scale in arcseconds per millimetre?

(A) 5.2 arcsec/mm

(B) 12.9 arcsec/mm

(C) 25.8 arcsec/mm

(D) 51.6 arcsec/mm

Answer: (C) **Difficulty:** Medium

Solution: Plate scale is $206\,265/f$ (with f in mm):

$$\text{Scale} = \frac{206\,265}{8000} \approx 25.8 \text{ arcsec/mm} \tag{5}$$

Q8

A photon of green light has wavelength $\lambda = 550$ nm. What is its energy in electronvolts?

(A) 0.80 eV

(B) 1.25 eV

(C) 2.26 eV

(D) 3.10 eV

Answer: (C) **Difficulty:** Easy

Solution:

$$E = \frac{hc}{\lambda} = \frac{1240 \text{ eV nm}}{550 \text{ nm}} \approx 2.26 \text{ eV} \tag{6}$$

Q9

A star's radius doubles while its surface temperature remains constant. By what factor does its luminosity change?

(A) 2

(B) 4

(C) 8

(D) 16

Answer: (B) **Difficulty:** Easy

Solution: $L = 4\pi R^2 \sigma T^4$. If $R \to 2R$ and T is constant: $L \to 2^2 L = 4L$.

Q10

For a main-sequence star of mass $M = 0.5\ M_\odot$, how bright is it in solar units if its luminosity scales with mass to the power 3.5 on the main sequence?

(A) $0.088\ L_\odot$

(B) $0.177\ L_\odot$

(C) $0.354\ L_\odot$

(D) $0.707\ L_\odot$

Answer: (A) **Difficulty:** Medium

Solution:

$$\frac{L}{L_\odot} = (0.5)^{3.5} = \frac{1}{2^{3.5}} = \frac{1}{2^3\sqrt{2}} = \frac{1}{11.31} \approx 0.088 \tag{7}$$

Q11

A neutron star has mass $M = 1.4\ M_\odot$ and radius $R = 10$ km. What is its average density?

(A) $4.0 \times 10^{14}\ \mathrm{kg/m^3}$

(B) $4.0 \times 10^{17}\ \mathrm{kg/m^3}$

(C) $4.0 \times 10^{20}\ \mathrm{kg/m^3}$

(D) $4.0 \times 10^{23}\ \mathrm{kg/m^3}$

Answer: (B) **Difficulty:** Medium

Solution:

$$\rho = \frac{M}{\frac{4}{3}\pi R^3} = \frac{1.4 \times 1.989 \times 10^{30}}{\frac{4}{3}\pi (10^4)^3} \approx 6.65 \times 10^{17}\ \mathrm{kg/m^3} \tag{8}$$

This is roughly $4 \times 10^{17}\ \mathrm{kg/m^3}$, consistent with nuclear density.

Q12

The Chandrasekhar limit marks the maximum mass of a stable white dwarf. What is this limit approximately?

(A) $0.5\ M_\odot$

(B) $1.0\ M_\odot$

(C) $1.4\ M_\odot$

(D) $3.0\ M_\odot$

Answer: (C) **Difficulty:** Easy

Solution: The Chandrasekhar limit is approximately $1.4\ M_\odot$. Above this mass, electron degeneracy pressure cannot support the white dwarf against gravitational collapse.

Q13

In a core-collapse supernova, approximately what fraction of the total gravitational binding energy is carried away by neutrinos?

(A) 1%

(B) 10%

(C) 50%

(D) 99%

Answer: (D) **Difficulty:** Easy

Solution: In a core-collapse supernova, about 3×10^{46} J is released in total, of which $\sim 99\%$ is carried away by neutrinos ($\sim 10^{58}$ neutrinos). Only $\sim 1\%$ goes into kinetic energy of the ejecta and radiation.

Q14

What does the "no-hair theorem" state about black holes?

(A) Black holes cannot emit Hawking radiation

(B) A black hole is completely characterised by mass, charge, and angular momentum

(C) Black holes have no event horizon

(D) Information falling into a black hole is always destroyed

Answer: (B) **Difficulty:** Easy

Solution: The no-hair theorem states that an isolated black hole is fully described by just three externally observable parameters: mass (M), electric charge (Q), and angular momentum (J). All other information about the matter that formed it is inaccessible.

Q15

A Type Ia supernova has an absolute magnitude $M_V \approx -19.3$. If it is observed with apparent magnitude $m_V = 15.7$, what is its distance?

(A) 10 Mpc

(B) 100 Mpc

(C) 316 Mpc

(D) 1000 Mpc

Answer: (B) **Difficulty:** Medium

Solution:

$$m - M = 5\log_{10} d - 5 \implies 15.7 - (-19.3) = 35.0 = 5\log_{10} d - 5 \tag{9}$$

$\log_{10} d = 40.0/5 = 8.0 \implies d = 10^{8.0}$ pc $= 100$ Mpc.

Q16

The gravitational binding energy of a uniform-density neutron star scales with the square of its mass and inversely with its radius. If the mass doubles while the radius stays the same, the binding energy:

(A) Doubles

(B) Quadruples

(C) Stays the same

(D) Halves

Answer: (B) **Difficulty:** Easy

Solution: Since $E \propto M^2/R$, doubling M at fixed R gives $E \to 2^2 E = 4E$.

Q17

The mass function of a spectroscopic binary is defined so that it is proportional to the cube of the radial-velocity semi-amplitude K and linearly to the orbital period P. If K doubles while P stays fixed:

(A) $f(M)$ doubles

(B) $f(M)$ quadruples

(C) $f(M)$ increases by a factor of 8

(D) $f(M)$ increases by a factor of 16

Answer: (C) **Difficulty:** Medium

Solution: $f(M) \propto K^3$, so doubling K gives $f(M) \to 2^3 f(M) = 8\,f(M)$.

Q18

A star with initial mass below approximately 8 $M_\odot$ will end its life as:

(A) A black hole
(B) A neutron star
(C) A white dwarf
(D) A supernova remnant only

Answer: (C) **Difficulty:** Easy

Solution: Stars with $M \lesssim 8\ M_\odot$ shed their outer layers as a planetary nebula, leaving behind a white dwarf. More massive stars produce neutron stars or black holes.

Q19

In a binary system, mass transfer from a donor star onto a compact companion through an accretion disk can power which observable phenomenon?

(A) Planetary nebula emission
(B) Type Ia supernova explosion
(C) X-ray binary luminosity
(D) Pulsar radio emission

Answer: (C) **Difficulty:** Easy

Solution: Accretion onto a neutron star or black hole in a binary system converts gravitational potential energy into thermal radiation, producing strong X-ray emission. These systems are called X-ray binaries.

Q20

A neutron star is observed to emit a burst of $\sim 10^{58}$ neutrinos lasting about 10 seconds. What does this most likely indicate?

(A) The neutron star is cooling
(B) A core-collapse supernova has occurred
(C) The neutron star is merging with a black hole
(D) The neutron star is a pulsar glitch

Answer: (B) **Difficulty:** Easy

Solution: A burst of $\sim 10^{58}$ neutrinos over $\sim$ 10 seconds is the hallmark of core-collapse supernovae. The gravitational binding energy of the proto-neutron star ($\sim 3 \times 10^{46}$ J) is carried away almost entirely by neutrinos.

Q21

The Sun is best classified as:

(A) A red dwarf
(B) A yellow dwarf
(C) A blue giant
(D) A white dwarf

Answer: (B) **Difficulty:** Very Easy

Solution: The Sun is a G2V main-sequence star with surface temperature ~ 5800 K, commonly called a yellow dwarf.

Q22

A black hole has a mass of $2.0 \times 10^7\ M_\odot$. Using $R_s \approx 3$ km $\times (M/M_\odot)$ and the fact that the shadow diameter is approximately $5.2 \times R_s$, what is its shadow diameter in AU?

(A) 0.02 AU
(B) 0.2 AU
(C) 2.0 AU
(D) 20 AU

Answer: (C) **Difficulty:** Medium

Solution:

$$R_s = 3 \times 2.0 \times 10^7 = 6.0 \times 10^7 \text{ km} \tag{10}$$

Shadow diameter $= 5.2 \times 6.0 \times 10^7 = 3.12 \times 10^8$ km $= 3.12 \times 10^8/(1.5 \times 10^8) \approx 2.0$ AU.

Q23

In a binary system, matter overflowing from a donor star forms a structure around the compact companion. What is this structure called?

(A) Roche lobe
(B) Accretion disk
(C) Schwarzschild radius
(D) Hertzsprung gap

Answer: (B) **Difficulty:** Easy

Solution: Transferred matter carries angular momentum and settles into a rotating accretion disk around the compact object, converting gravitational energy into thermal radiation.

Q24

What is the approximate luminosity of the Sun?

(A) 3.8×10^{23} W

(B) 3.8×10^{26} W

(C) 3.8×10^{29} W

(D) 3.8×10^{32} W

Answer: (B) **Difficulty:** Very Easy

Solution: The Sun's luminosity $L_\odot \approx 3.8 \times 10^{26}$ W is a fundamental astrophysical constant that must be memorised.

Q25

Which class of objects is commonly used as a standard candle for measuring cosmic distances?

(A) Cepheid variables and Type Ia supernovae

(B) Black holes and dark matter halos

(C) Planetary rings and comet tails

(D) Solar wind and meteor showers

Answer: (A) **Difficulty:** Medium

Solution: Standard candles have calibratable intrinsic luminosities. Cepheid variables and Type Ia supernovae are key rungs of the cosmic distance ladder.

Q26

Which phenomenon is most directly analogous to the mechanism that generates planetary magnetic fields?

(A) Planetary Migration

(B) Doppler Wobble

(C) Dynamo Effect

(D) Baryon Acoustic Oscillations

Answer: (C) **Difficulty:** Easy

Solution: The dynamo effect—the generation of a magnetic field by the motion of an electrically conducting fluid—is the leading theoretical mechanism for planetary magnetic fields.

Q27

In modern structure formation, why do galaxies grow hierarchically over cosmic time?

(A) Smaller dark-matter halos and galaxies merge into larger systems
(B) Galaxies expand because individual stars physically grow larger
(C) The CMB pushes galaxies together through radiation pressure
(D) Heavy elements form first and later become hydrogen

Answer: (A) **Difficulty:** Hard

Solution: In Lambda-CDM cosmology, small density perturbations collapse first. Larger galaxies and clusters then assemble through accretion and mergers of smaller halos.

Q28

During which process did hydrogen and helium form in significant amounts from the hot, dense early universe?

(A) Big Bang Nucleosynthesis
(B) Metric Expansion of Space
(C) Star Formation in the early universe
(D) Primordial nucleosynthesis in stars

Answer: (A) **Difficulty:** Easy

Solution: Big Bang Nucleosynthesis (BBN) occurred in the first few minutes of the universe, producing hydrogen, helium, and trace amounts of lithium.

Q29

Elements heavier than iron were not produced in significant quantities during the Big Bang. Why?

(A) Star formation was still ongoing and supernova count was insufficient
(B) The early universe lacked enough space to accommodate the elements
(C) The amount of matter was insufficient to supplement heavy-element fusion
(D) The BBN window was too brief for heavier-than-beryllium elements to form

Answer: (D) **Difficulty:** Medium

Solution: BBN was too brief (minutes) and the universe cooled too quickly for fusion chains to proceed beyond light elements. Heavier elements require the sustained high temperatures and densities found only in stellar cores and supernovae.

Q30

What is the approximate current temperature of the Cosmic Microwave Background (CMB) radiation?

(A) 2.73 K

(B) 27.3 K

(C) 273 K

(D) 3.0 K

Answer: (A) **Difficulty:** Easy

Solution: The CMB is a nearly perfect blackbody with temperature $T_0 \approx 2.725$ K, uniform across the sky.

Q31

According to the Lambda-CDM model, what constituent makes up the largest percentage of the total energy density of the modern universe?

(A) Dark Energy

(B) Dark Matter

(C) Normal Baryonic Matter

(D) Electromagnetic Radiation

Answer: (A) **Difficulty:** Easy

Solution: Dark energy accounts for $\sim 68\%$ of the total energy density, dark matter $\sim 27\%$, and baryonic matter only $\sim 5\%$.

Q32

The CMB temperature at redshift $z = 10$ was approximately 30.0 K. What was it at $z = 1100$ (recombination)?

(A) 3000 K

(B) 30 000 K

(C) 300 000 K

(D) 3 000 000 K

Answer: (A) **Difficulty:** Medium

Solution:

$$T = T_0(1 + z) = 2.73 \times (1 + 1100) \approx 2.73 \times 1101 \approx 3006 \text{ K} \approx 3000 \text{ K} \tag{11}$$

Q33

Cosmological observations estimate $\Omega_m = 0.31$ and $\Omega_\Lambda = 0.69$. If the critical density is ρ_c, what is the total density parameter Ω, and what does this imply for the geometry?

(A) $\Omega = \rho_c$; the universe is open

(B) $\Omega = 0.31\,\rho_c$; the universe is closed

(C) $\Omega = 1.0$; the universe is flat

(D) $\Omega = 1.31\,\rho_c$; the universe is flat

Answer: (C) **Difficulty:** Medium

Solution:

$$\Omega = \Omega_m + \Omega_\Lambda = 0.31 + 0.69 = 1.0 \tag{12}$$

An Ω of exactly 1 means $\rho = \rho_c$, corresponding to a geometrically flat universe.

Q34

The historic discovery of the CMB in 1964 by Penzias and Wilson was achieved using which type of instrument?

(A) An optical space telescope

(B) A large horn radio antenna

(C) A laser interferometer

(D) A particle accelerator

Answer: (B) **Difficulty:** Easy

Solution: Penzias and Wilson accidentally discovered the CMB as persistent background noise while using the Holmdel Horn Antenna designed for satellite communication tracking.

Q35

Kepler wants a spacecraft to orbit Earth at $r = 8000$ km. What circular orbital speed is required?

(A) 5.06 km/s

(B) 7.06 km/s

(C) 8.94 km/s

(D) 11.2 km/s

Answer: (B) **Difficulty:** Medium

Solution: Equating gravitational and centripetal acceleration gives the circular orbital speed $v = \sqrt{\mu/r}$:

$$v = \sqrt{\frac{\mu}{r}} = \sqrt{\frac{398\,600}{8000}} = \sqrt{49.825} \approx 7.06 \text{ km/s} \tag{13}$$

Q36

An engineer doubles a circular orbit's radius around the same planet. What happens to the orbital speed?

(A) It decreases by a factor of $\sqrt{2}$

(B) It doubles

(C) It stays the same

(D) It becomes zero

Answer: (A) **Difficulty:** Easy

Solution: Circular speed $v = \sqrt{GM/r} \propto 1/\sqrt{r}$. Doubling r reduces v by a factor of $\sqrt{2}$.

Q37

A satellite travels in an elliptical orbit about Earth with perigee distance $r_p = 7000$ km and apogee distance $r_a = 14\,000$ km. What is its speed at perigee?

(A) 6.5 km/s

(B) 8.7 km/s

(C) 10.3 km/s

(D) 11.2 km/s

Answer: (B) **Difficulty:** Medium

Solution: Using the vis-viva equation $v = \sqrt{\mu(2/r - 1/a)}$, first find the semimajor axis as the average of perigee and apogee:

$$a = \frac{r_p + r_a}{2} = \frac{7000 + 14\,000}{2} = 10\,500 \text{ km} \tag{14}$$

At perigee, $r = r_p = 7000$ km. Evaluate the quantity inside the square root step by step:

$$\frac{2}{r} - \frac{1}{a} = \frac{2}{7000} - \frac{1}{10\,500} \tag{15}$$

$$\frac{2}{7000} = 2.857 \times 10^{-4}, \qquad \frac{1}{10\,500} = 9.524 \times 10^{-5} \tag{16}$$

$$\frac{2}{r} - \frac{1}{a} = 2.857 \times 10^{-4} - 9.524 \times 10^{-5} = 1.905 \times 10^{-4} \text{ km}^{-1} \tag{17}$$

$$v = \sqrt{398\,600 \times 1.905 \times 10^{-4}} = \sqrt{75.9} \approx 8.7 \text{ km/s} \tag{18}$$

Q38

A spacecraft in a circular orbit at altitude $h = 400$ km above Earth's surface has period $P \approx 92$ min. If it boosts to a circular orbit at $h = 36\,000$ km (geostationary), the period will be:

(A) 12 hours

(B) 24 hours
(C) 48 hours
(D) 72 hours

Answer: (B) **Difficulty:** Medium

Solution: Geostationary orbits by definition have a period equal to Earth's sidereal rotation period, approximately 23 h 56 min $\approx$ 24 hours.

Q39

Which mission visited Jupiter, Saturn, Uranus, and Neptune?

(A) Viking 1
(B) Apollo 8
(C) Voyager 2
(D) Mariner 2

Answer: (C) **Difficulty:** Easy

Solution: Voyager 2 is the only spacecraft to have visited all four giant planets during its Grand Tour trajectory (1977–present).

Q40

Where does the International Space Station orbit?

(A) Low Earth orbit
(B) Lunar orbit
(C) Sun–Earth L2
(D) Mars orbit

Answer: (A) **Difficulty:** Easy

Solution: The ISS orbits in low Earth orbit at an altitude of approximately 400 km above Earth's surface.