PHYSICS

A star overhead appears to rotate in a cone of a very small angle over a year. If the orbital speed of the earth is 30 km/s, the value of θ is approximately

A 50.0 sec of arc   **C** 35.0 sec of arc

**B** 20.5 sec of arc   **D** 70.5 sec of arc

Observation indicates that the Universe is continuously expanding. The distance between two objects is therefore a function of time $d(t)$, which may be written as $d(t) = a(t)d_\circ$, where $d_\circ$ is the distance at some fixed time $t_\circ$ and the scale factor $a(t)$ gives the expansion. Using the first law of thermodynamics $dE = -p\,dV$ and the equation of state for a gas of photons (radiation) $p = \rho/3$, the dependence of the (energy) density ρ as a function of $a(t)$ is of the type:

A $\rho \sim 1/a^4(t)$ **C** $\rho \sim a^3(t)$

B $\rho \sim 1/a^3(t)$ **D** $\rho \sim a^4(t)$

A pressurized tank at $27°C$ contains 4.0 mol of argon gas. The rms speed of argon atoms is (Atomic mass of argon is 29.96 ; k = $1.38 \times 10^{-23}\,JK^{-1}$)

A zero   **B** 25 ms^{-1} **C** 3966 ms^{-1} **D** 431 ms^{-1}

The equivalent capacitance of the combination of capacitors shown is
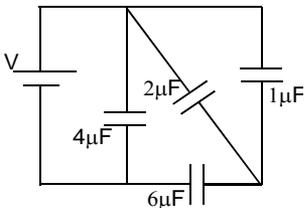
A 2 μF **B** 4 μF **C** 6 μF **D** 13 μF

A mass m of water at temperature T is mixed adiabatically with an equal mass of water at temperature 4T. The entropy change of the universe is (s: specific heat)

A zero   **B** $2ms\ln\dfrac{5}{4}$ **C** $ms\times\dfrac{3T}{2}$ **D** $-ms\times\dfrac{3T}{2}$

The headlights of a truck are separated by 2m and emit yellow light. The maximum distance from where our eye (aperture of the eye is approximately 1 mm) can resolve the two headlights is close to

A 1.4 km   **B** 2.8 km   **C** 3.3 km   **D** 3.8 km

A partially polarized light i.e. a mixture of polarized and unpolarized light is passed through a polarizer. When the polarizer is rotated through $360°$ while keeping it perpendicular to the beam, the transmitted intensity varies by a factor of 5 during rotation. The fraction of the intensity of the original beam associated with polarized light is

A 0.20   **B** 0.33   **C** 0.50   **D** 0.66

Phosphorous is doped in silicon with concentration 10^{18} cm^{-3}. Its donor level is 0.045 eV below the conduction band edge. At room temperature (300 K), the number of donor electrons per cm^3 in the silicon conduction band is

A 10^{14} **B** 10^{13} **C** 10^{12} **D** 10^{17}

A charged liquid drop of charge Q and radius R breaks into two equal drops, each carrying charge $\dfrac{Q}{2}$. The process (ignoring surface tension effect)

A releases energy.   **C** conserves energy.

B absorbs energy.   **D** is impossible.

The K line of singly ionized calcium has a wavelength of 393.3 nm on earth. In the spectrum of an observed galaxy, this line has a wavelength 401.8 nm. The speed with which the galaxy is moving away from us is

A $3 \times 10^8 \, ms^{-1}$ **C** $6480 \, kms^{-1}$

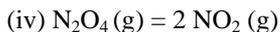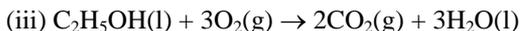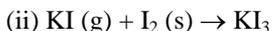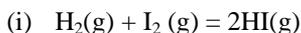**B** $30 \, kms^{-1}$ **D** $3240 \, kms^{-1}$

CHEMISTRY

The composition of air inhaled by a person is 21% by volume O_2 and 0.03% CO_2 and that of exhaled air is 15% O_2 and 5.2% CO_2. Assuming ideal behavior and inhalation of a typical volume of 7200 L of air per day, the mass of O_2 used by the body of the person at the body temperature (37 °C) and 1 atmospheric pressure is,

A 450.5 g   **B** 537.6 g   **C** 621.2 g   **D** 379.6 g

The half-life period of a reaction increases four-fold when the initial concentration of the reactant is increased four times. The order of the reaction is

A 1   **B** 2   **C** 3   **D** 0

In the following reactions

(i) $H_2(g) + I_2 (g) = 2HI(g)$

(ii) $KI (g) + I_2 (s) \rightarrow KI_3$

(iii) $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

(iv) $N_2O_4 (g) = 2 \, NO_2 (g)$

which will have $\Delta H = \Delta E$?

A reaction (i)   **C** reactions (ii) and (iv)

B reactions (i) and (ii)   **D** reactions (iii) and (iv)

A S_N2 reaction at an asymmetric carbon atom with R configuration, always leads to a

A S compound

B R compound

C mixture of S and R compounds

D compound with inversion at the asymmetric center

Compound A reacts with acetic acid in the presence of Hg^{+2} salts to give an adduct B ($C_4H_6O_2$) which gives acetic acid and acetaldehyde on hydrolysis. Compounds A and B are

A propyne and propyl acetate   **C** ethene and vinyl acetate

B ethyne and vinyl acetate   **D** ethyne and ethyl formate

The compound with least acidic hydrogen (indicated by circle) is expected to be

A

B

C

D

If the x-direction is the bond axis, which one among the following combinations for the diatomic molecule AB will have zero overlap

A s (A) and p_x (B)   **C** p_x (A) and p_z (B)

B s (A) and p_y (B)   **D** p_z (A) and p_z (B)

The statement that is incorrect about dimeric aluminium chloride in the vapour phase is

A There are four chlorine atoms around each aluminium.

B There are two types of Al-Cl bonds.

C There are two types of Al-Cl-Al angles.

D There are three types of Cl-Al-Cl angles

X (at wt. 60.2) crystallizes in a body centered cubic lattice. The number of unit cells in 2.0 g of X is

A 10^{22} **B** 10^{23} **C** 2×10^{22} **D** 2×10^{23}

Oxides AO and BO have melting points of 2800 and 1920 °C, respectively. Solubility of ACl_2 in water is much greater than that of AF_2. A and B, respectively, are

A Mg and Ba   **C** Ca and Ba

B Ba and Mg   **D** Ba and Ca

BIOLOGY

The blood glucose level of an otherwise normal individual had shot up above normal. Through which one of the mechanisms given below the condition was returned to normal?

A glucose was removed by dialysis

B glucose was taken up from blood by the pancreas

C insulin action on liver, muscle and adipose cells led to their uptake of glucose and subsequent conversion to glycogen

D glucose was excreted

If human cells are cultured in the presence of radioactive thymidine, the radioactive label would be incorporated into,

A nucleus and Golgi bodies   **C** cell membrane

B DNA in nucleus and mitochondria   **D** mRNA

A silent mutation in the coding region of a gene leads to,

A generation of a stop codon

B silencing of the function of the protein

C appearance of the consequences of mutation in F2 generation

D change of codon that codes for the same or similar amino acid

Terrestrial reptiles excrete their nitrogen waste as uric acid. This is advantageous to the embryos growing in shelled eggs because,

A uric acid is the source of nitrogen required for the growing embryo

B uric acid stabilizes the egg shell

C uric acid is insoluble and hence non-toxic to the embryo

D uric acid is converted to urea and ammonia

Enzymes catalyze chemical reactions in living cells. Heat treatment of most enzymes leads to loss of catalytic property. This is due to,

A change in enzyme sequence at high temperature

B loss of 3-dimensional structure of enzymes

C breakdown of enzyme into amino acids

D breakdown of enzyme into peptides

Two bacterial genomes of 200 bp and 400 bp sizes are replicated in a test tube four times. How many molecules of each will you have at the end of the reaction ?

A 8 molecules of each

B 16 molecules of 200 bp and 8 molecules of 400 bp

C 16 molecules of each

D 8 molecules of 200 bp and 16 molecules of 400 bp

During photosynthesis, CO_2 is fixed into glucose. During this process O_2 is released.

A the oxygen arises from CO_2

B the oxygen arises from H_2O

C the oxygen is taken up from air along with CO_2 and released from stomata

D the oxygen is a by-product of the biosynthesis of the chlorophyll prosthetic group

Two antibiotics A and B kill 99% of bacteria by two different mechanisms depending on concentration. Which of the following will kill more bacteria?

A A and B given together.

B A and B given sequentially.

C 2 x A and B given together.

D 2 x A and B given sequentially.

One of the two strands of a B-DNA contains 30 adenines and 20 cytosines. The number of Hydrogen bonds in this DNA is

A 130   **B** 120   **C** 150   **D** 100

When inhabitants of low land areas travel to high altitudes, their body physiology undergoes adaptive changes to acclimatize to the low oxygen content of the air. Which of the following is correct?

A the number of RBCs increases rapidly.

B the hemoglobin content per RBC increases.

C the hemoglobin undergoes alteration so as to bind more oxygen.

D the total blood cell count increases rapidly.