


## JGEEBILS GS2019

### Section A: General


1.

Ontario, a province in Canada, is nearly 6 times larger than the state of Karnataka, yet it houses fewer species of plants and animals than its Indian counterpart. This is most likely because:

- a. Karnataka has a higher human population
- b.  Karnataka is closer to the equator
- c. Ontario is west of Karnataka
- d. Ontario gets more precipitation per year


2.

You have been asked to measure the wingspans of a set of birds of the same species. As your sample size (the number of wingspans you measure) increases, what will a graph of standard deviation vs. sample size look like?

- a. Increasing
- b. Decreasing
- c. Constant (flat)
- d.  Fluctuating (sometimes increasing, sometimes decreasing)


3.

When you are writing a paper, which of the following actions does not require you to cite the source?

- a.  Reusing a standard abbreviation from a published paper
- b. Reusing a sentence from a published paper
- c. Reusing a paragraph from the methods section of a published paper
- d. Reusing a paragraph from Wikipedia


4.

When viewed in sunlight, a flower has red petals and a green stalk. You pluck the flower and take it to a room illuminated with a red lamp. What colours does the flower now appear to be?

- a. Black petals and a green stalk
- b. Black petals and a black stalk
- c.  Red petals and a black stalk
- d. Red petals and a green stalk

5.

India faced heavy floods this year in Uttarakhand and Kerala. This is most likely due to:

- a. Pollution
- b.  Land use change
- c. El Niño
- d. Seismic activity

6.

The speed of the Earth orbiting the sun is

- a. the same at all points along its orbit
- b.  fastest at a single fixed point on its orbit
- c. fastest at two fixed points on its orbit
- d. slowest at two fixed points on its orbit

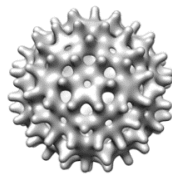
7.

What is the output range of the function  $y = 1 - \exp(x)$  for input values in the interval  $-\infty < x < \infty$ ?

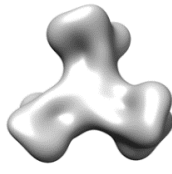
- a.  $-\infty < y < \infty$
- b.  $0 < y < \infty$
- c.   $-\infty < y < 1$
- d.  $0 < y < 1$

8.

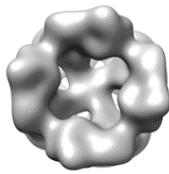
We say a shape has more symmetries if there are more ways it can be rotated, flipped or moved to get back the same shape. Below are images of four different macromolecules labelled A to D. Order them from low to high symmetry.



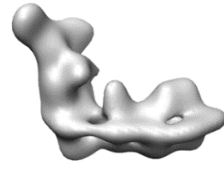
(A)



(B)



(C)

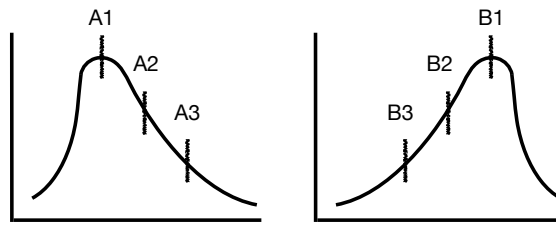


(D)

- a. D, C, A, B
- b. B, A, D, C
- c.  D, B, C, A
- d. A, D, C, B

9.

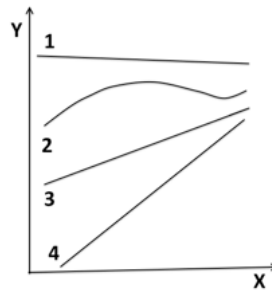
Identify the three measures of central tendency in the following distributions:



- a. ✓ A1 and B1= mode, A2 and B2 = median, A3 and B3 = mean
- b. A1 and B3= mode, A2 and B2 = median, A3 and B1 = mean
- c. A3 and B1= mode, A2 and B2 = median, A1 and B3 = mean
- d. A1 and B1= median, A2 and B2 = mode, A3 and B3 = mean

10.

Observe the curves numbered 1, 2, 3 and 4 in this plot. For each of these curves at several evenly-spaced values of X, you measure the slope  $dY/dX$ . For which curve will you observe the largest variance in measured values of  $dY/dX$ ?



- a. Curve 1
- b. ✓ Curve 2
- c. Curve 3
- d. Curve 4

11.

Consider the following statements.

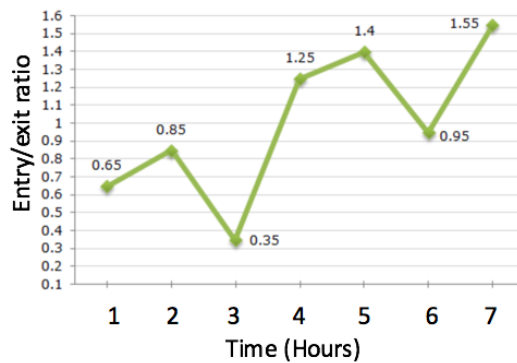
- I. Some fairies are pixies
- II. All pixies are magicians
- III. No magicians are trolls

Based on the above statements, which of the following is correct:

- a. Some trolls are pixies
- b.  Some fairies are magicians
- c. All magicians are pixies
- d. All pixies are fairies

12.

The following line graph gives the ratio of the amount of entry to the amount of exit of a specific molecule from a cell, over the time period 1-7 hours. If the entry at 4 hours was 250 units and the total exit at 4 hours and 5 hours together was 500 units, then the entry at 5 hours was:



- a. 250 units
- b. 300 units
- c. 357 units
- d.  420 units

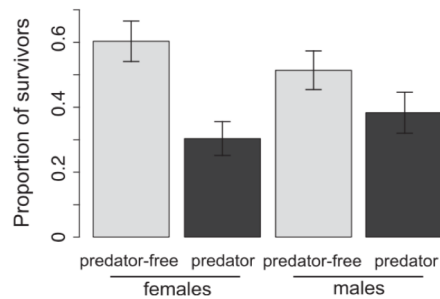
13.

Which of the following is the largest?

- a. ✓  $100^{1/100}$
- b.  $100^{1/101}$
- c.  $10^{1/51}$
- d.  $10^{1/52}$

14.

Scientists marked and released 100 lizards on 4 islands. Each island is home to predators. After a month they trapped and counted all surviving marked lizards. They then repeated the experiment, but after removing all predators from each island. Their results are summarised below. Which of the following inferences can you make from this plot?




- a. Predators have no impact on lizard survival
- b. ✓ Predators have a bigger impact on female survival than male survival
- c. Some islands did not have any predators to begin with
- d. Females survival is twice that of males, but only in the presence of predators

15.

What is the output of the following pseudocode program, which first defines a function 'whoosh' and then calls it from a for-loop?

```
define whoosh(n)
    if n is equal to 1
        return 1
    else
        return n + whoosh(n-1)
    endif
end define


for i = 1 to 5
    print whoosh(i)
endfor
```

- a. 1, 2, 3, 4, 5
- b. 1, 1, 2, 3, 5
- c.  1, 3, 6, 10, 15
- d. 1, 2, 6, 24, 120

## Section B: Physics


1.

You are running up a spiral staircase. The associated angular momentum points in which direction?

- a. Upwards
- b. Downwards
- c. The net displacement is linear, so there is no angular momentum
- d.  The answer cannot be determined from the information given


2.

Which of the following best explains why the refractive index of water changes with temperature?

- a.  Due to change in density
- b. Due to change in surface tension
- c. Due to change in viscosity
- d. Due to evaporation

3.


A particle is constrained to move in a circle with a 10-metre radius. At one instant, the particle speed is 10 m/s and its speed is increasing with a rate of  $10 \text{ m/s}^2$ . What is the angle between the particle velocity and acceleration vectors?

- a. 0 degrees
- b. 30 degrees
- c.  45 degrees
- d. 90 degrees




4.

A charged particle is released from rest in a region where there is a constant electric field and a constant magnetic field. If the two fields are parallel to each other, the path of the particle is a

- a. circle
- b.  straight line
- c. helix
- d. parabola


5.

A ray of light is incident on a mirror and the light travels in the direction  $\hat{x} + \sqrt{3}\hat{y}$  and after reflection, travels in the direction  $\hat{x}$ . What is the angle of incidence with respect to the normal to the mirror?

- a. 30 degrees
- b.  60 degrees
- c. 90 degrees
- d. 120 degrees

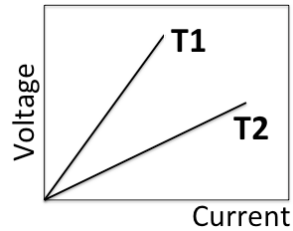
6.

You have a system of non-interacting particles that can exist in three possible states, with energy  $0, E, 2E$  ( $E > 0$ ). At a temperature  $T = E/k_B$  (where  $k_B$  = Boltzmann's constant) the energy states are occupied in approximately the ratio

- a. 1 : 1 : 1
- b. 1 : 0.5 : 0.25
- c. 1 : 2.72 : 7.39
- d.  1 : 0.37 : 0.14

7.

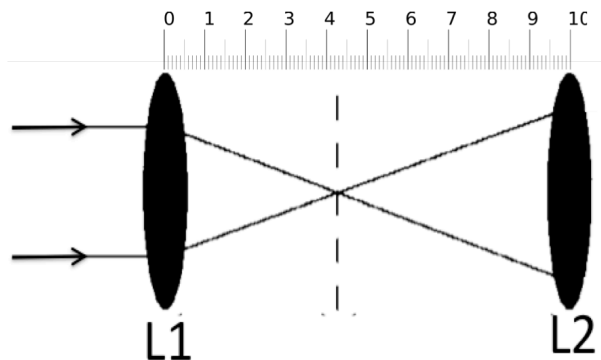
The voltage measured across a metal bar is plotted as a function of applied current, at two different temperatures (T1 and T2). Which of the following statements is correct?



- a.  T1 is greater than T2
- b. T2 is less than T1
- c. T1 is equal to T2
- d. T1 could be less than or greater than T2 depending on which metal it is

8.

Two identical bi-convex lenses L1 and L2 are arranged 10 cm apart. A collimated, parallel beam of light strikes L1 from the left and converges 4.3 cm from the left lens. The emergent rays on the right of L2 will be



- a. parallel
- b.  convergent
- c. divergent
- d. polarised

9.

Standing waves are excited in a 1 m long pipe open at one end, closed at the other. Take the speed of the wave as 340 m/s and calculate the frequency of the first overtone (i.e. the first harmonic above the fundamental frequency).

- a. 128 Hz
- b. 170 Hz
- c. ✓ 255 Hz
- d. 510 Hz

10.

In a certain process  $1.5 \times 10^5$  Joules of heat is added to an ideal gas to keep the pressure at  $2.0 \times 10^5$  Pa while the volume expands from  $6.3 \text{ m}^3$  to  $7.1 \text{ m}^3$ . What is the change in internal energy for the gas?

- a. It decreases by  $2.0 \times 10^5$  J
- b. It increases by  $1.0 \times 10^5$  J
- c. It increases by  $1.0 \times 10^3$  J
- d. ✓ It decreases by  $1.0 \times 10^4$  J

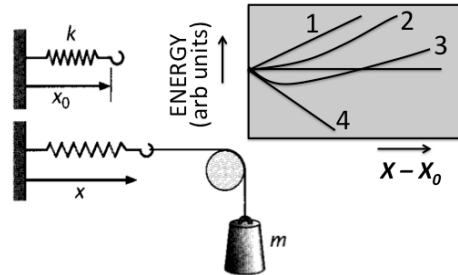
11.

Consider the following "logistic" equation that describes the growth of a population of organisms:  $dx/dt = x(1 - x)$ . The stabilities of the fixed (equilibrium) points are:

- a.  $x = 0$  (stable) and  $x = 1$  (stable)
- b.  $x = 0$  (stable) and  $x = 1$  (unstable)
- c. ✓  $x = 0$  (unstable) and  $x = 1$  (stable)
- d.  $x = 0$  (unstable) and  $x = 1$  (unstable)

12.

Note the spring-and-mass arrangement below. With no mass the spring has a rest length  $x_0$ . Now a mass  $m$  is introduced as shown. Which curve in the gray box best represents the variation in TOTAL energy of this system?



- a. Curve number 1
- b. Curve number 2
- c.  Curve number 3
- d. Curve number 4

13.

A particle of mass  $m$  undergoes harmonic oscillations with period  $T$ , about  $x = 0$ . Now a force  $F$  is applied to the particle, acting opposite in direction to its instantaneous velocity:  $F = -kv$ . What happens when the particle is released from rest from some  $x > 0$ :

- a. It undergoes a steady oscillation with a period larger than  $T$
- b. It undergoes a decaying oscillation
- c. It no longer oscillates, it moves in one direction with decreasing speed
- d.  It could oscillate or not, depending on parameter values

14.

Which one of the following quantities is invariant under Lorentz transformation?

- a. Charge density
- b. ✓ Charge**
- c. Current
- d. Electric field

15.


If  $|0\rangle$  and  $|1\rangle$  represent an orthonormal basis for the states of a single qubit, which of the following represents an entangled state of two qubits A and B? (The subscript labels the state of the respective subsystem A or B.)

- a.  $|0\rangle_A + |1\rangle_B$
- b.  $(|0\rangle_A + |1\rangle_B)/\sqrt{2}$
- c.  $|0\rangle_A \otimes |1\rangle_B$
- d. ✓  $(|0\rangle_A \otimes |1\rangle_B + |1\rangle_A \otimes |0\rangle_B)/\sqrt{2}$**

## Section C: Chemistry

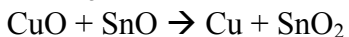
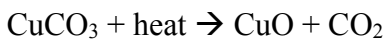
1.


Element Y has a nucleon number of 19 and a proton number of 9. Which group in the Periodic Table does it belong to?

- a. Group I
- b. Group III
- c.  Group VII
- d. Group VIII

2.


Which statement is true for the following chemical reactions?



- a.  $\text{CO}_2$  is oxidized and  $\text{SnO}_2$  is reduced
- b.  $\text{CuCO}_3$  is oxidized and  $\text{CuO}$  is reduced
- c.  $\text{CuO}$  is oxidized and  $\text{SnO}$  is reduced
- d.   $\text{SnO}$  is oxidized and  $\text{CuO}$  is reduced

3.

Dinitrogen tetroxide ( $\text{N}_2\text{O}_4$ ) breaks down into nitrogen dioxide ( $\text{NO}_2$ ). If the reaction is reversible and endothermic, which condition will give the largest yield of  $\text{NO}_2$ ?

- a. High temperature and high pressure
- b.  High temperature and low pressure
- c. Low temperature and high pressure
- d. Low temperature and low pressure

4.

Which of the following molecules will have a dipole moment?

- a.  $\text{CH}_4$
- b.   $\text{NH}_3$
- c.  $\text{CCl}_4$
- d.  $\text{CO}_2$

5.

When a non-volatile solute is dissolved in a pure solvent, the difference between the freezing points of the solvent alone and the solution is

- a.  positive
- b. negative
- c. zero
- d. none of the above

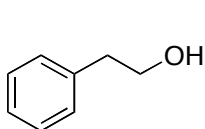
6.

A helium atom is heavier than a hydrogen molecule. At 298 K, the average kinetic energy of a helium atom is

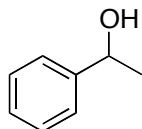
- a. twice that of a hydrogen molecule
- b.  equal to that of a hydrogen molecule
- c. four times that of a hydrogen molecule
- d. half that of a hydrogen molecule

7.

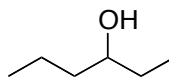
Among the following, the one that gives positive Iodoform test upon reaction with  $I_2$  and  $NaOH$  is:



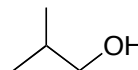
(A)



(B)



(C)



(D)

- a. Molecule (A)
- b.  Molecule (B)
- c. Molecule (C)
- d. Molecule (D)

8.

For an endothermic reaction, where  $\Delta H$  represents the enthalpy of the reaction in kJ/mol, the minimum value for the energy of activation will be:

- a. Less than  $\Delta H$
- b. Zero
- c.  More than  $\Delta H$
- d. Equal to  $\Delta H$

9.


Which of the following amino acids is commonly used in catalysis by enzyme?

- a. Alanine
- b. Arginine
- c.  Serine
- d. Methionine




10.

Which of the following compounds does not undergo ozonolysis reaction?

- a. 3-methyl-1-butene
- b.  2,3-dimethyl-butane
- c. 2-methyl-2-butene
- d. 2-methyl-1-butene


11.

4.8g of gas at 27°C occupied the same volume as 1g of hydrogen at 17°C and at the same pressure. What is the molecular weight of the gas?

- a. 0.1 g
- b. 0.48 g
- c. 5.2 g
- d.  9.9 g


12.

Consider a reversible reaction  $A \rightleftharpoons B$  with forward and backward rate constants  $k_+ = k_- = 1 \text{ sec}^{-1}$ . Suppose we start with a 1 molar solution of  $A$ . How long will the concentration of  $A$  take to reach 0.75 molar?

- a. 0.25 sec
- b.  $\ln(4/3) \sim 0.29 \text{ sec}$
- c.   $\ln(\sqrt{2}) \sim 0.35 \text{ sec}$
- d. It will never reach that concentration


13.

Which compound is most acidic?

- a.  $\text{H}_2\text{O}$
- b.  $\text{H}_2\text{S}$
- c.   $\text{H}_2\text{Se}$
- d.  $\text{NH}_3$


14.

Labelling of proteins with iodine is used for tracing. Which amino acid does iodine react with.

- a. Alanine
- b. Aspartate
- c. Lysine
- d.  Tyrosine

15.


You are given an oligonucleotide whose molecular weight is 10000 Daltons. Assuming you want to make 100  $\mu\text{l}$  of 100  $\mu\text{M}$  stock how much oligonucleotide would you need?

- a. 10  $\mu\text{g}$
- b. 1  $\mu\text{g}$
- c.  100  $\mu\text{g}$
- d. 1000  $\mu\text{g}$

## Section D: Biology


1.

Glucokinase phosphorylates glucose in liver only when glucose levels are higher than normal. What property of glucokinase is responsible for this?

- a. High molecular weight
- b.  High  $K_m$
- c. High  $V_{max}$
- d. Ability to act equally on D- and L-glucose


2.

Platelets contain

- a. Both genomic and mitochondrial DNA
- b.  Only mitochondrial DNA
- c. Only genomic DNA
- d. No DNA


3.

Protein X is composed of 700 amino acids. When resolved on denaturing PAGE it shows a band corresponding to 130 kDa. The probable reason for such discrepancy is

- a. Dimerization of the protein
- b.  Glycosylation of the protein
- c. Phosphorylation of the protein
- d. Acetylation of the protein


4.

A geneticist crossed two pure-bred (homozygous) tall and short plants. In the F1 generation she observed that all the offspring were of intermediate height. If she crosses one of the offspring with the short parent what kind of progeny would you expect? Assume that plant height is dictated by a single locus.

- a. All short
- b. 50 % tall and 50 % short
- c.  50 % intermediate and 50 % short
- d. 50 % intermediate, 25 % tall and 25 % short


5.

How would you test whether a phenotypic difference between two populations of a plant is due to environmentally induced plasticity or evolutionary adaptation?

- a. DNA sequencing
- b. RNA sequencing
- c. Grow both populations in different greenhouses
- d.  Grow both populations in the same greenhouse

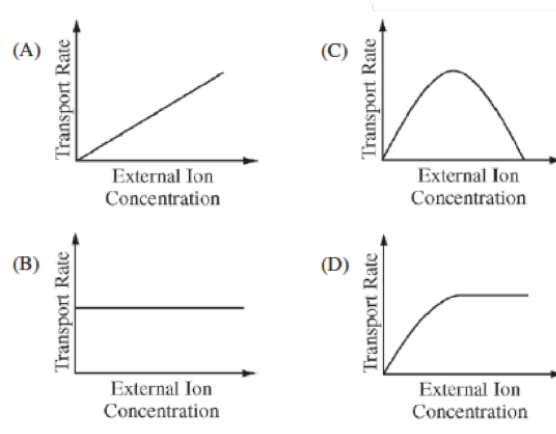
6.

In an experiment, two fly populations are separately maintained for many generations. Population A contains closely-related individuals. Population B contains a set of unrelated individuals. Over many generations it is observed that the fitness of individuals in population A is lower than the fitness of those in population B. Why?

- a. Close relatives will not mate with one another
- b. Close relatives compete for common resources more than unrelated individuals
- c.  The offspring of close relatives harbour more deleterious recessive mutations
- d. Unrelated individuals are likely to contain new high-fitness genes

7.

Of the graphs shown below, which is most representative of the kinetics of ion transport through a membrane channel?



- a. Graph (A)
- b. Graph (B)
- c. Graph (C)
- d. ✓ Graph (D)


8.

Galvani discovered in the 1700s that frog's legs jerked when touched with a piece of copper and a piece of iron, simultaneously. This happens because action potentials are triggered due to which of the following properties of the metals:

- a. Metals conduct charge away from cell membranes
- b. Soluble metal ions mimic neurotransmitters
- c. The temperature difference between metals and tissues
- d. ✓ The electrochemical potential difference between the two metals


9.

Human red blood cells (RBCs) cannot be grown in cultures because

- a. RBCs require a steady oxygen supply
- b. RBCs are extremely fragile
- c.  RBCs are terminally differentiated cells
- d. RBCs are biconcave


10.

Which one of the following cannot form a bilayer by itself?

- a. Glycerophospholipids
- b.  Cholesterol
- c. Phosphatidic acid
- d. Glycerolipids

11.

The poison dart frog, or poison arrow frog in the family Dendrobatidae carry Batrachotoxin, among other agents. The toxin irreversibly binds to voltage-gated sodium channels and keeps them open. Why does this paralyze and kill you?

- a. The ionic gradient gets lost and the nerve cells die
- b.  Synapses remain active so muscles cannot relax
- c. The metabolic cost of pumping sodium ions exhausts the ATP reserves of cells
- d. All pain-conducting nerves become active simultaneously

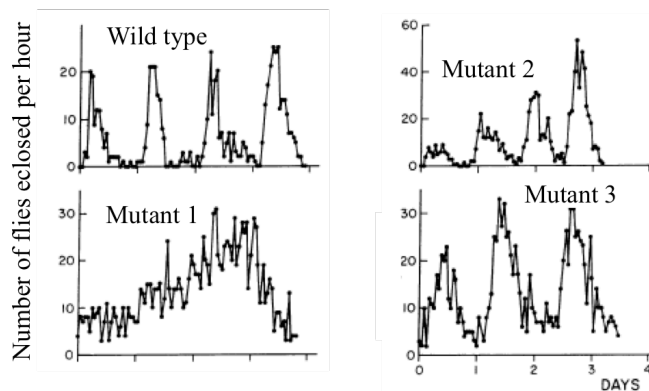
12.

The monoamine serotonin is synthesized mainly by enterochromaffin cells in the intestine. A mouse was treated with broad range of antibiotics for a week. After a week, both the diversity of gut microbiota and serum serotonin levels was reduced. In another independent study, a co-culture of *Lactobacillus* and enterochromaffin cells induced serotonin synthesis. Based on these observations, the reason for decreased serum serotonin in antibiotic treated mouse would most likely be

- a. Antibiotics inhibit serotonin synthesis
- b. ✓ Gut microbiota play an important role in serotonin biosynthesis
- c. Antibiotics make the mouse depressed and hence reduce the levels of serotonin
- d. Antibiotics degrade serum serotonin

13.

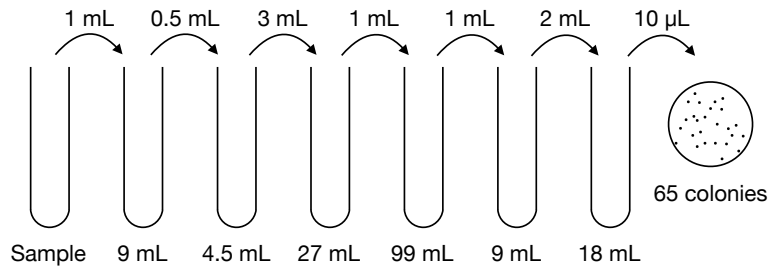
Konopka and Benzer isolated mutant fruit flies that had abnormal daily (circadian) rhythms. The graph below shows the number of fruitflies that eclose each hour of the day (eclosion means emergence from the pupal case). Which of these statements can be reasonably deduced from the given data?



- a. ✓ The wildtype has a 24 hour rhythm
- b. The mutation in Mutant 1 causes lethality
- c. The rhythm is abolished in Mutant 2
- d. Mutant 2 and Mutant 3 have mutations on different protein-coding genes

14.

How many bacteria were there in the initial 1 ml sample based on the dilution series shown below? The labels below the tube show the amount of liquid before the transfer. Assume no cell death, and assume that all bacteria successfully form colonies when plated.



- a.  $6.5 \times 10^8$
- b.  $6.5 \times 10^9$
- c. ✓  $6.5 \times 10^{10}$
- d.  $6.5 \times 10^{11}$




15.

Thyroxin is the major hormone produced by the thyroid gland. Rats may be thyroidectomised (THX) either surgically or chemically. In an experiment designed to investigate the relationship of the thyroid gland to metabolism (i.e. oxygen consumption) and protein synthesis, following data were recorded. Experimental and control animals were tested by measuring oxygen consumption in a respirometer for 1 hour and by measuring incorporation of injected tritiated leucine ( $^3\text{H}\text{-Leu}$ ) in the liver. Post-injection, rats were sacrificed at various time points and radioactivity in the liver was measured.

	$^3\text{H}\text{-Leu}$ incorporation (mmoles/g/hr)	Oxygen consumption (ml/g/hr)
Normal rats with Thyroid	214	32.6
THX rats	156	23.4

Based on the above description, which of the following control experiment should also be performed to confirm the relationship of thyroxin to respiration and protein synthesis?

- a. Inject untritiated leucine in the THX rats and take the measurements again
- b. Inject untritiated leucine in the normal rats and take the measurements again
- c.  Inject Thyroxin in the THX rats and take the measurements again
- d. Inject Thyroxin in the normal rats and take the measurements again