

## Sample Questions

1. The fuel in the buster rockets of the Space Shuttle is constituted of a mixture of ammonium perchlorate,  $\text{NH}_4\text{ClO}_4$ , and aluminum powder. One of the reactions taking place during taking off is given by

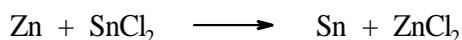


The indication (s) and (g) signify solid and gaseous phase. Suppose that these rockets are loaded with 11.75 tons of ammonium perchlorate and 2.70 tons of aluminum. Calculate the volume of nitrogen gas produced during taking off under normal conditions ( $0^\circ\text{C}$  and atmospheric pressure, so that 1 mol of gas corresponds to 22.4 L)

- (A)  $6.72 \cdot 10^2$  L  
 (B)  $1.12 \cdot 10^3$  L  
 (C)  $7.47 \cdot 10^4$  L  
 (D)  $6.72 \cdot 10^5$  L  
 (E)  $1.12 \cdot 10^6$  L
2. If a small zinc rod is put into a solution of tin(II)chloride,  $\text{SnCl}_2$ , tin will precipitate on the zinc rod and zinc will go into solution as  $\text{Zn}^{2+}$  ions.

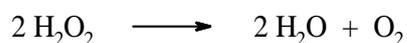


If a lead rod is put into the same tin(II)chloride solution, no precipitation is observed.



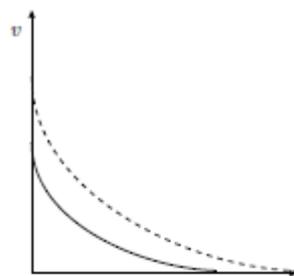
What is your conclusion?

- (A) Lead is a stronger reductor than zinc  
 (B) Tin is a stronger reductor than zinc  
 (C) Zinc is a stronger reductor than lead  
 (D) Tin is a stronger oxidator than zinc  
 (E)  $\text{Zn}^{2+}$  ions are a stronger oxidator than  $\text{Pb}^{2+}$  ions
3. Hydrogen peroxide,  $\text{H}_2\text{O}_2$ , spontaneously decomposes in water and oxygen gas

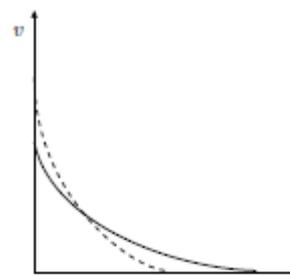


The reaction is one time performed without catalyst (full line) and one time in the presence of a catalyst (dashed line), starting from the same initial amount of hydrogen peroxide.

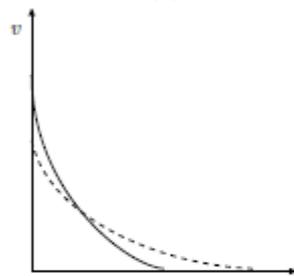
Which of the diagrams gives the correct reaction rate ( $v$ ) as function of time (horizontal axis)?



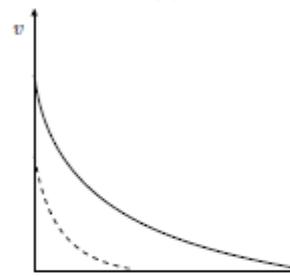
(A)



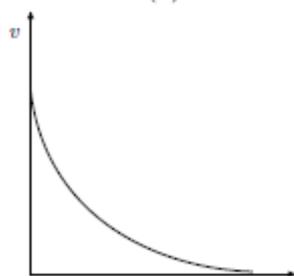
(B)



(C)

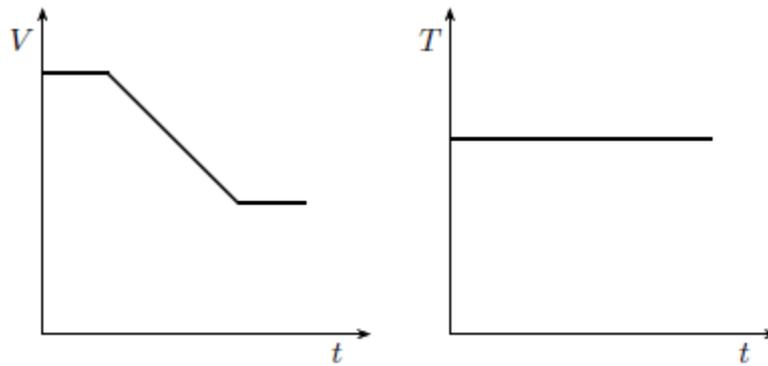


(D)

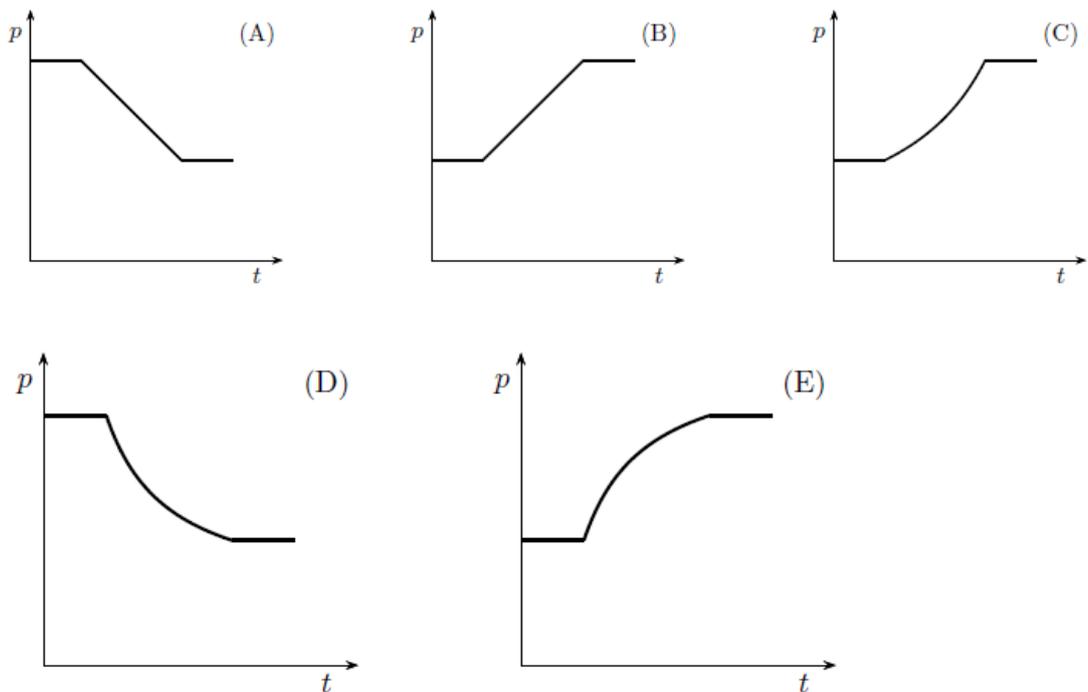


(E)

4. A cylinder with movable piston is filled with an ideal gas. Hence, the relation  $pV = nRT$  holds ( $n$  is the number of moles). Next figures show the relation of the volume ( $V$ ) and the temperature ( $T$ ) as function of time.

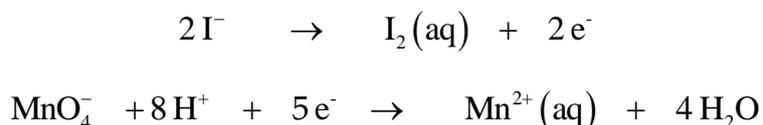


Which graph represents the correct pressure  $p$  as function of time?



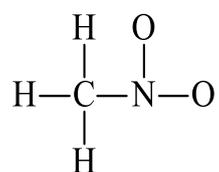
5. Sulfuric acid has a molar mass of 98 g/mol. In the laboratory there is 100 mL of a 0.10 M sulfuric acid solution. How much water needs to be added to this volume to prepare a solution containing 4.9 g/L of sulfuric acid?
- (A) 10 mL
  - (B) 50 mL
  - (C) 100 mL
  - (D) 150 mL
  - (E) 200 mL

6. The ion-electron equations for a redox reaction are given by



How many moles of iodide ions are oxidised by one mole of permanganate ions?

- (A) 0.2  
(B) 0.4  
(C) 1  
(D) 2  
(E) 5
7. If the atomic number of an atom is represented by X and the mass number is represented by Y, the number of neutrons in an atom of this element is  
(A)  $Y - X$   
(B)  $X - Y$   
(C)  $X + Y$   
(D) Y
8. Which of the following is the correct arrangement of electrons in a phosphorus atom (atomic number 15) ?  
(A) 2, 8, 4, 1  
(B) 2, 8, 5  
(C) 5, 8, 2  
(D) 2, 5, 8  
(E) 2, 4, 8, 1
9. In the  $\text{CH}_3\text{NO}_2$  molecule, shown below, what hybrid orbital set is used by the nitrogen atom for bonding? Be sure to check the Lewis structure to make sure it is correct?



- (A) sp
- (B) sp<sup>2</sup>
- (C) sp<sup>3</sup>
- (D) sp<sup>3</sup>d
- (E) sp<sup>3</sup>d<sup>2</sup>

10. Which of the following temperatures has an equal value expressed in °C and °F?

- (A) -40
- (B) -22.2
- (C) 0
- (D) 22.2
- (E) +40

11. Consider the function  $f: \mathbb{R} \rightarrow \mathbb{R}: x \mapsto x \cos(x^2)$ . Evaluate the derivative of  $f$  at the point  $\sqrt{2\pi}/2$ .

- (A)  $f'(\sqrt{2\pi}/2) = -\pi$
- (B)  $f'(\sqrt{2\pi}/2) = -\sqrt{2\pi}$
- (C)  $f'(\sqrt{2\pi}/2) = \sqrt{2\pi}$
- (D)  $f'(\sqrt{2\pi}/2) = 0$
- (E)  $f'(\sqrt{2\pi}/2) = 1 - \sqrt{2\pi}$

12. Consider a natural number  $m \neq 0$ . Evaluate  $\lim_{n \rightarrow \infty} \frac{nm}{m-n}$ .

- (A)  $\frac{m}{m-1}$
- (B)  $m$
- (C) 1
- (D) -1
- (E)  $-m$

13. Consider the circle with equation  $y^2 - 2y + x^2 + 6x - 15 = 0$ . If  $M = (a, b)$  is its center and  $R$  its radius, then  $2a + b + R^2$  is equal to

- (A) 10
- (B) 14
- (C) 20
- (D) 24
- (E) 30

14. Evaluate  $\int \frac{e^{\sqrt{x}}}{\sqrt{x}} dx$ .
- (A)  $e^{\sqrt{x}} + \text{constant}$   
 (B)  $2e^{\sqrt{x}} + \text{constant}$   
 (C)  $e^{-\sqrt{x}} + \text{constant}$   
 (D)  $\sqrt{x}e^{\sqrt{x}} + \text{constant}$   
 (E)  $\frac{1}{2}e^{\sqrt{x}} + \text{constant}$
15. The trigonometric expression  $\frac{1}{\cos x \tan x} - \sin x$  equals
- (A)  $\frac{1}{\sin x}$   
 (B)  $\frac{\tan x}{\sin x}$   
 (C)  $\frac{(\sin x)^2}{\cos x}$   
 (D)  $\frac{\cos x}{\sin x}$   
 (E)  $\frac{(\cos x)^2}{\sin x}$
16. A function  $f: A \rightarrow B: x \mapsto f(x)$  is a one-to-one function if for all  $x, y \in A$  it holds that: if  $x \neq y$ , then  $f(x) \neq f(y)$ . Determine which of the following functions is one-to-one.
- (A)  $f: \mathbb{N} \times \mathbb{N} \rightarrow \mathbb{N}: (n, m) \mapsto m + n$   
 (B)  $f: \mathbb{N} \times \mathbb{N} \rightarrow \mathbb{N}: (n, m) \mapsto mn$   
 (C)  $f: \mathbb{N} \times \mathbb{N} \rightarrow \mathbb{N}: (n, m) \mapsto 3^m 5^n$   
 (D)  $f: \mathbb{N} \times \mathbb{N} \rightarrow \mathbb{N}: (n, m) \mapsto m^n$   
 (E)  $f: \mathbb{N} \times \mathbb{N} \rightarrow \mathbb{N}: (n, m) \mapsto 2^{m+n}$
17. Consider the function  $f: \mathbb{R} \rightarrow \mathbb{R}: x \mapsto x - \sqrt{x^2 + 5x}$ . Which of the following statements is true?
- (A)  $f$  is increasing on its domain.  
 (B)  $f$  is decreasing on its domain.  
 (C)  $f$  has two distinct zeros.  
 (D)  $f(x) \leq 0$  for all  $x$  in its domain.  
 (E)  $f$  has both negative as positive values on its domain
18. Suppose  $a, b, c$  and  $d$  are real numbers such that  $ab < cd$  and  $0 < a < c$ . Which of the following statements is definitely true?
- (A)  $a < cd$   
 (B)  $b < d$   
 (C)  $a < \frac{cd}{b}$   
 (D) If  $d < 0$ , then  $b < 0$ .  
 (E) If  $b < 0$ , then  $d < 0$ .

19. The function  $\text{sgn}$  is defined as follows:  $\text{sgn}(x) = \begin{cases} \frac{x}{|x|}, & x \neq 0 \\ 0, & x = 0 \end{cases}$ . Evaluate

$$\int_0^4 x \text{sgn}(2-x) dx.$$

- (A) 8
- (B) 4
- (C) 0
- (D) -4
- (E) -8

20. Suppose  $f: \mathbb{R} \rightarrow \mathbb{R}$  is a differentiable function such that  $f(x) \geq 0$  for all  $x \in \mathbb{R}$  and  $P(5,9)$  is a point on the graph of  $f$ . The tangent line to the curve of  $f$  at  $P$  intersects the x-axis at the point  $Q(1,0)$ . If a function  $h$  is defined as  $h: \mathbb{R} \rightarrow$

$\mathbb{R}: x \mapsto \sqrt{f(x)}$ , then  $h'(5)$  equals:

- (A)  $\frac{3}{8}$
- (B)  $\frac{3}{2}$
- (C)  $\frac{1}{6}$
- (D)  $\frac{9}{8\sqrt{5}}$
- (E)  $\frac{2}{27}$

Correct answers:

- 1) D
- 2) C
- 3) B
- 4) C
- 5) C
- 6) E
- 7) A
- 8) B
- 9) B
- 10) A
- 11) A
- 12) E
- 13) C
- 14) B
- 15) E
- 16) C
- 17) D
- 18) D
- 19) D
- 20) A

## GUGC Aptitude Test – Covered Topics

### **Chemistry:**

Elements, mixtures

Lavoisier Law

Symbolic representation of atoms and molecules, atomic mass, unit of atomic mass, electrons and nucleons (protons and neutrons)

Oxidation number, ion and ion charge

Reactions between bases and acids

Reaction equations: ion exchange reactions, precipitation reactions, combustion reactions, synthesis reactions pH calculations, titration and titration reactions

Bohr atom model, Bohr-Sommerfeld model, electron spin, Pauli rule

Energy levels: s, p, d, f and orbitals (basic knowledge)

Electronegativity, electron pairs

Covalent and ionic bonds, metal bonds

Lewis notation from binary compounds and polyatomic compounds

Polar and apolar compounds Intermolecular forces

Nomenclature anorganic and organic compounds and ions (basic level)

Stoichiometry: molar mass, molar volume, Avogadro constant, ideal gas law, mass density

Concentration and concentration units, calculation of masses, volumes, concentrations, excess and limiting reagentia

Reaction rate: factors influencing reaction rate, explanation via collision theory model

Chemical equilibrium: equilibrium constant, factors influencing chemical equilibrium, calculations with equilibrium data

Redox reactions: completion of redox reactions and interpretation of oxidators and reductors

Sigma and pi bonds

Solubility of ionic compounds

Basic thermochemistry (enthalpy, entropy, free energy) for simple chemical reactions

Electrode potentials

### **Mathematics:**

Algebra: Quadratic equation, binomial theorem, arithmetic, geometric and harmonic means and series, theory of equations, vectors, matrix algebra, complex numbers.

Trigonometry: trigonometric functions, formulae and equations, relations between sides and angles of a triangle.

Two-dimensional analytical/coordinate geometry: Cartesian coordinates, locus, equation of a straight line, equation of a circle.

Differential calculus: functions of a real variable, limits and continuity, derivatives, geometrical interpretation of the derivative, maximum and minimum values of functions.

Integral calculus: indefinite and definite integrals, integration by parts, substitution, partial fractions, areas under curves.