HOLY SPIRIT UNIVERSITY OF KASLIK
Faculty of Engineering

Entrance Exam
August 21, 2013

Duration: 4 hours

Number of pages: 31

- Page 1 : Front page
- Pages 2 to 11 : Mathematics
  40 questions - 60 points
- Pages 12 to 17 : Physics
  25 questions - 25 points
- Pages 18 to 22 : Chemistry
  20 questions - 20 points
- Pages 23 to 26 : General knowledge
  30 questions - 10 points
- Pages 27 to 31 : 5 scrap sheets

- Each question has only one correct answer: choose only one answer per question.
- Answer on the answer sheets.
- Do not detach the scrap sheets.
- Any fraud attempt fraud will be sanctioned by the cancellation of the examination.
- The use of non-programmable calculators is allowed.
- The use of mobile phones is PROHIBITED.
Mathematics
40 questions - 60 points

1) In the space referred to a direct orthonormal system \((O; \vec{i}, \vec{j}, \vec{k})\), consider the straight lines \(D_1\) and \(D_2\) of respective parametric representations:
\[
\begin{align*}
  x &= 4 + t \\
  y &= 6 + 2t \\
  z &= 4 - t \\
&\text{where } t \text{ is a real parameter} \\
\end{align*}
\[
\begin{align*}
  x &= 8 + 5t' \\
  y &= 2 - 2t' \\
  z &= 6 + t' \\
&\text{where } t' \text{ is a real parameter.}
\end{align*}
\]

a) The straight line \(D_1\) and \(D_2\) are parallel.
b) The straight line \(D_1\) and \(D_2\) are perpendicular.
c) The straight line \(D_1\) and \(D_2\) are coplanar.
d) The straight line \(D_1\) and \(D_2\) are identical.

2) In the space referred to a direct orthonormal system \((O; \vec{i}, \vec{j}, \vec{k})\), consider the plan \(P\) of Cartesian equation \(x + y + 3z + 4 = 0\) and the point \(S(1, -2, -2)\). The parametric representation of the straight line passing through \(S\) and perpendicular is:
\[
\begin{align*}
  x &= 2 + t \\
  y &= -1 + t \text{ where } t \text{ is a real parameter} \\
  z &= 1 + 3t \\
\end{align*}
\]
a) \(y = -1 + t \text{ where } t \text{ is a real parameter}\)

b) \(y = -1 + t \text{ where } t \text{ is a real parameter}\)

\[
\begin{align*}
  x &= 2 - t \\
  z &= 1 + 3t \\
\end{align*}
\]

c) \(y = 1 + t \text{ where } t \text{ is a real parameter}\)

\[
\begin{align*}
  x &= 2 + t \\
  z &= 1 + 3t \\
\end{align*}
\]

d) \(y = -1 + t \text{ where } t \text{ is a real parameter}\)

\[
\begin{align*}
  x &= 2 + t \\
  z &= 1 - 3t \\
\end{align*}
\]

3) In the space referred to a direct orthonormal system \((O; \vec{i}, \vec{j}, \vec{k})\), consider the point \(A(12, 7, -13)\) and the plan \(P\) of Cartesian equation \(3x + 2y - 5z = 1\). The orthogonal projection of point \(A\) onto plane \(P\) is point \(B\) with coordinates:

a) \((1, 2, 3)\)
b) \((3, 1, 2)\)
c) \((2, 3, 1)\)
d) \((1, 3, 2)\)

4) Consider the cube \(ABCDEFGH\). The straight lines \((EC)\) and \((BG)\) are:

a) intersecting
b) coplanar
c) orthogonal
d) perpendicular
5) Which of the functions $f, g, h$ and $k$ defined below has a period equals to $\pi$?
   a) $f(x) = \sin x + \cos x$
   b) $g(x) = \sin x \times \cos x$
   c) $h(x) = (\sin x)^3$
   d) $k(x) = \sin(3x)$

6) Which one of the following equalities is false?
   a) $\lim_{x \to +\infty} \frac{e^t}{x} = +\infty$
   b) $\lim_{x \to -\infty} \frac{e^t}{x} = -\infty$
   c) $\lim_{x \to +\infty} \frac{\ln x}{x} = 0$
   d) $\lim_{x \to 0} x \ln x = 0$

7) In the space referred to a direct orthonormal system $(O; \vec{i}, \vec{j}, \vec{k})$, consider the plane $P_1$ of Cartesian equation $x + y + z = 0$ and the plane $P_2$ of equation $x + 4y + 2 = 0$. $P_1$ and $P_2$, intersect on a straight line whose parametric representation is:
   a) \begin{align*}
   x &= 4t + 2 \\
   y &= t \\
   z &= 3t + 2 \\
   \end{align*} \\
   where $t$ is a real parameter
   b) \begin{align*}
   x &= -4t - 2 \\
   y &= -t \\
   z &= 3t + 2 \\
   \end{align*} \\
   where $t$ is a real parameter
   c) \begin{align*}
   x &= -4t - 2 \\
   y &= t \\
   z &= 3t - 2 \\
   \end{align*} \\
   where $t$ is a real parameter
   d) \begin{align*}
   x &= -4t - 2 \\
   y &= t \\
   z &= 3t + 2 \\
   \end{align*} \\
   where $t$ is a real parameter

8) $\int_{0}^{1} \frac{1}{1 + e^{-x}} \, dx =$
   a) $\ln \left( \frac{1 + e}{2} \right)$
   b) $\ln (1 + e)$
   c) $\ln \left( \frac{e - 1}{2} \right)$
   d) $\ln (e - 1)$
9) On the interval $]0 ; +\infty [$, the equation $(\ln x)^2 - \ln x = 1$ admits the following solutions:
   a) $x_1 = e^{1+\sqrt{\pi}}$ and $x_2 = e^{1-\sqrt{\pi}}$
   b) $x_1 = e^{1+\sqrt{\pi}}$ and $x_2 = e^{1+\sqrt{\pi}}$
   c) $x_1 = e^{\frac{1-\sqrt{\pi}}{2}}$ and $x_2 = e^{\frac{1+\sqrt{\pi}}{2}}$
   d) $x_1 = e^{\frac{1-\sqrt{\pi}}{2}}$ and $x_2 = e^{\frac{1+\sqrt{\pi}}{2}}$

10) $\int_{1}^{\infty} \ln x \, dx =$
   a) $1$
   b) $e$
   c) $e-1$
   d) $1-e$

11) On the interval $]0 ; +\infty [$, function $g$ defined by $g(x) = (\ln x)^2$ admits a primitive function $G$ defined by:
   a) $G(x) = \frac{(\ln x)^3}{3} + K ; \ K \in \mathbb{R}$
   b) $G(x) = \frac{x(\ln x)^3}{3} + K ; \ K \in \mathbb{R}$
   c) $G(x) = x[(\ln x)^2 - 2\ln x] + K ; \ K \in \mathbb{R}$
   d) $G(x) = x[(\ln x)^2 - 2\ln x + 2] + K ; \ K \in \mathbb{R}$

12) Consider the arithmetic sequence $(u_n)$ defined by $u_0 = 1$ and, for every integer $n$, $u_{n+1} = \frac{1}{3}u_n + 4$.
    For every integer $n$, let $v_n = u_n - 6$ . the sequence $(v_n)$ is:
    a) an arithmetic sequence of common difference $-2$.
    b) an arithmetic sequence of common difference $\frac{1}{3}$.
    c) a geometric sequence of ratio $-2$.
    d) a geometric sequence of ratio $\frac{1}{3}$.

13) $g$ is a function defined on the interval $]-\infty ; 0]$ by $g(x) = \sqrt{x^2 - 2x}$. We denote by $\Gamma$ its representative curve in the plane referred by an orthonormal system.
   a) $\Gamma$ admits as asymptote the straight line of Cartesian equation $y = -1$.
   b) $\Gamma$ admits $0$ asymptote.
   c) $\Gamma$ admits as asymptote the straight line of Cartesian equation $y = x$.
   d) $\Gamma$ admits as asymptote the straight line of Cartesian equation $y = 1$. 
14) Given function \( f \) defined on \( \mathbb{R} \) by \( f(x) = \int_0^x e^{-t^2} \, dt \). The function \( f'' \), second derivative of \( f \) on \( \mathbb{R} \), is defined by:

a) \( f''(x) = -\int_0^x 2te^{-t^2} \, dt \)

b) \( f''(x) = -\frac{1}{2} \int_0^x te^{-t^2} \, dt \)

c) \( f''(x) = -2xe^{-x^2} \)

d) \( f''(x) = -\frac{1}{2} xe^{-x^2} \)

15) Which one of the following statements is false?

a) A complex number \( z \) is a pure imaginary number if and only if \( z = -z \).

b) A complex number \( z \) is a real number if and only if \( z = \overline{z} \).

c) For every complex number \( z \), we have: \( z\overline{z} = |z|^2 \).

d) For every complex number \( z \), we have: \( z\overline{z} = 1 \)

16) Given function \( f \) defined on \( ]-\infty, 0[ \cup ]0, +\infty[ \) by \( f(x) = x-1 - \frac{4}{e^x-1} \). Let (C) be its representative curve in an orthonormal system \((O;\overrightarrow{i}, \overrightarrow{j})\). (C) admits as a center of symmetry the point whose coordinates are:

a) \((0; 0)\)

b) \((0; 1)\)

c) \((1; 1)\)

d) \((1; 0)\)

17) Given function \( f \) defined on \( ]1; +\infty[ \) by \( f(x) = x - \frac{1}{x\ln x} \). We have:

a) \( f''(x) = 1 + \frac{\ln x + 1}{x^2 \ln^2 x} \)

b) \( f''(x) = 1 + \frac{\ln x - 1}{x^2 \ln^2 x} \)

c) \( f''(x) = 1 - \frac{\ln x - 1}{x^2 \ln^2 x} \)

d) \( f''(x) = 1 - \frac{\ln x + 1}{x^2 \ln^2 x} \)
Questions 18 and 19 are linked questions:

Given the differential equation (E): \( y' - ye^x + 1 = 0 \).

18) Let \( z = y - xe^x - 1 \). We can show that:
   a) \( z = Ce^{2x} \); \( C \) is a real constant
   b) \( z = Ce^{-x} \); \( C \) is a real constant
   c) \( z = Ce^x \); \( C \) is a real constant
   d) \( z = Ce^{-2x} \); \( C \) is a real constant

19) The particular solution of (E) which verifies \( y(0) = 0 \) is:
   a) \( y = -e^{2x} + xe^{2x} + 1 \)
   b) \( y = -e^x + xe^x + 1 \)
   c) \( y = -e^{-x} + xe^{-x} + 1 \)
   d) \( y = -e^{-2x} + xe^{-2x} + 1 \)

Questions 20 and 21 are linked questions:

In the complex plane referred to a direct orthonormal system \((O; \vec{u}, \vec{v})\), consider the points A, B and C with respective affixes \( a = 2 \), \( b = 3 \) and \( c = 2\sqrt{3} \).

20) A measure of angle \( ABC \) is:
   a) \( \frac{\pi}{2} + 2k\pi \); \( k \in \mathbb{Z} \)
   b) \( \frac{\pi}{3} + 2k\pi \); \( k \in \mathbb{Z} \)
   c) \( \frac{\pi}{4} + 2k\pi \); \( k \in \mathbb{Z} \)
   d) \( \frac{\pi}{6} + 2k\pi \); \( k \in \mathbb{Z} \)

21) We can deduce that the affix of the center of the circumscribed circle of triangle \( ABC \) is equal to:
   a) \( 2 - \sqrt{3} i \)
   b) \( 2 + \sqrt{3} i \)
   c) \( 1 - \sqrt{3} i \)
   d) \( 1 + \sqrt{3} i \)
Questions 22 and 23 are linked questions:

Consider two urns U and V. U contains three balls labeled 0 and two balls labeled 1. Urn V contains five balls labeled from 1 to 5. We draw at random one ball from each urn and we designate by X the product of the two labels of the balls drawn.

22) \( P(X = 0) = \)
   a) \( \frac{4}{5} \)
   b) \( \frac{3}{5} \)
   c) \( \frac{2}{5} \)
   d) \( \frac{1}{5} \)

The ten balls of urns U and V are now placed in urn W. We draw simultaneously and at random two balls from urn W. We designate by Y the product of the two labels of the balls drawn.

23) \( P(Y = 0) = \)
   a) \( \frac{8}{15} \)
   b) \( \frac{1}{5} \)
   c) \( \frac{3}{5} \)
   d) \( \frac{2}{3} \)

Questions 24 and 25 are linked questions:

Consider function \( g \) defined on \( ]0; +\infty[ \) by \( g(x) = 2x^3 - 1 + 2\ln x \).

24) On \( ]0; +\infty[ \), function \( g \):
   a) is strictly decreasing.
   b) is strictly increasing.
   c) admits a minimum.
   d) admits a maximum.

25) On the interval \( ]0; +\infty[ \), function \( g \) is null on the point of abscissa \( \alpha \) such that:
   a) \( 0,84 < \alpha < 0,85 \)
   b) \( 0,85 < \alpha < 0,86 \)
   c) \( 0,86 < \alpha < 0,87 \)
   d) \( 0,87 < \alpha < 0,88 \)
Questions 26 to 30 are linked questions:
Consider the function \( f \) defined in the interval \([0; +\infty[\) by \( f(x) = 2x - \frac{\ln x}{x^2} \). Let (C) be its representative curve in an orthogonal system \((O; i, j)\).

Graphical units: 2 cm on x-axis and 1 cm on y-axis.

26) \( C \) admits as oblique asymptote the straight line \( (D) \) of Cartesian equation:
   a) \( y = 2x \)
   b) \( y = -2x \)
   c) \( y = 2x - 1 \)
   d) \( y = -2x - 1 \)

27) The curve \( C \) and the straight line \( (D) \) intersect at point \( A \) with coordinates:
   a) \((1; 2)\)
   b) \((1; -2)\)
   c) \((1; 1)\)
   d) \((1; -3)\)

Let \( n \) be a non-zero integer and let \( D \) be the area of the plans delimited by the curve \( C \), the straight line \( (D) \) and the straight lines of respective Cartesian equations \( x = 1 \) and \( x = n \) where \( n > 1 \).

28) The area of the domain \( D \), expressed in cm\(^2\), is given by:
   a) \( I_n = \frac{1}{2} \int_1^n \frac{\ln x}{x^2} \, dx \)
   b) \( I_n = \int_1^n \frac{\ln x}{x^2} \, dx \)
   c) \( I_n = 2 \int_1^n \frac{\ln x}{x^2} \, dx \)
   d) \( I_n = 4 \int_1^n \frac{\ln x}{x^2} \, dx \)

29) We can show that:
   a) \( I_n = \frac{1}{2} \frac{n-1-\ln n}{n} \)
   b) \( I_n = \frac{n-1-\ln n}{n} \)
   c) \( I_n = 2 \frac{n-1-\ln n}{n} \)
   d) \( I_n = 4 \frac{n-1-\ln n}{n} \)
30) When \( n \) approaches \(+\infty\), we have:

a) \( \lim_{n \to +\infty} I_n = \frac{1}{2} \)

b) \( \lim_{n \to +\infty} I_n = 1 \)

c) \( \lim_{n \to +\infty} I_n = 2 \)

d) \( \lim_{n \to +\infty} I_n = 4 \)

Questions 31 to 33 are linked questions:

Let \( g \) be the function defined on \([0 ; +\infty[\) by \( g(x) = 2\left(\frac{e^{4x} - 1}{e^{4x} + 1}\right) \) and we denote by \((C_g)\) its representative curve in an orthogonal system \( (O ; \overrightarrow{i}, \overrightarrow{j}) \).

31) For every real number \( x \) of interval \([0 ; +\infty[\) we have:

a) \( g'(x) = 4 - [g(x)]^2 \)

b) \( g'(x) = 4 + [g(x)]^2 \)

c) \( g'(x) = 8 - [g(x)]^2 \)

d) \( g'(x) = 8 + [g(x)]^2 \)

32) The curve \((C_g)\) admits:

a) one horizontal asymptote only.

b) one vertical asymptote only.

c) one horizontal asymptote and one vertical asymptote.

d) 0 asymptote.

33) The Cartesian equation of the tangent to \((C_g)\) at point of abscissa 0 is:

a) \( y = x \)

b) \( y = 2x \)

c) \( y = 3x \)

d) \( y = 4x \)
Questions 34 to 37 are linked questions:

Let \( g \) be the function defined on \( \mathbb{R} \) by \( g(x) = 4xe^{2x} + 1 \).
Let \( f \) be the function defined on \( \mathbb{R} \) by \( f(x) = x + (2x-1)e^{2x} \). We denote by \((C)\) the representative curve of \( f \) in an orthogonal system \((O;\vec{i}, \vec{j})\).

34) \( g(x) \) admits:
   a) a maximum at point with coordinates \((-\frac{1}{2}; 1-\frac{2}{e})\)
   b) a minimum at point with coordinates \((-\frac{1}{2}; 1-\frac{2}{e})\)
   c) a maximum at point with coordinates \((\frac{1}{2}; 1+\frac{2}{e})\)
   d) a minimum at point with coordinates \((\frac{1}{2}; 1+\frac{2}{e})\)

35) Which one of the following statements is true?
   a) For every real number \( x \), \( g(x) > 0 \).
   b) For every real number \( x \), \( g(x) < 0 \).
   c) For \( x < \frac{1}{2} \) we have \( g(x) < 0 \) and for \( x > \frac{1}{2} \) we have \( g(x) > 0 \).
   d) For \( x < \frac{1}{2} \) we have \( g(x) > 0 \) and for \( x > \frac{1}{2} \) we have \( g(x) < 0 \).

36) \( \lim_{x \to +\infty} \frac{f(x)}{x} = \)
   a) 0
   b) 1
   c) \(-\infty\)
   d) \(+\infty\)

37) Which one of the following statements is true?
   a) \((C)\) admits at \(+\infty\) a parabolic branch parallel to the \( y \)-axis.
   b) \((C)\) admits at \(-\infty\) a parabolic branch parallel to the \( y \)-axis.
   c) \((C)\) admits at \(+\infty\) a parabolic branch parallel to the \( x \)-axis.
   d) \((C)\) admits at \(-\infty\) a parabolic branch parallel to the \( x \)-axis.
Questions 38 to 40 are linked questions:

Consider two urns $U_1$ and $U_2$. Urn $U_1$ contains 4 tokens numbered from 1 to 4. Urn $U_2$ contains 4 white balls and 6 black balls.

A game consists on drawing a token from urn $U_1$, the on drawing simultaneously and at random from urn $U_2$ as many balls as it is indicated on the token drawn.

We consider the following events:

$E_1$ « The token drawn from urn $U_1$ is labeled 1 »

$E_2$ « The token drawn from urn $U_1$ is labeled 2 »

$E_3$ « The token drawn from urn $U_1$ is labeled 3 »

$E_4$ « The token drawn from urn $U_1$ is labeled 4 »

$B$ « All the balls drawn from urn $U_2$ are white»

38) The probability of event $B$ knowing that event $E_1$ has occurred is:

a) $P_{E_1}(B) = \frac{1}{5}$

b) $P_{E_1}(B) = \frac{2}{5}$

c) $P_{E_1}(B) = \frac{1}{15}$

d) $P_{E_1}(B) = \frac{2}{15}$

39) The probability of event $B$ knowing that event $E_2$ has occurred is:

a) $P_{E_2}(B) = \frac{1}{5}$

b) $P_{E_2}(B) = \frac{2}{5}$

c) $P_{E_2}(B) = \frac{1}{15}$

d) $P_{E_2}(B) = \frac{2}{15}$

40) The probability of event $B$ is:

a) $P(B) = \frac{1}{5}$

b) $P(B) = \frac{1}{6}$

c) $P(B) = \frac{1}{7}$

d) $P(B) = \frac{1}{8}$
Physics
25 questions - 25 points

1) The following resonant circuit consists of an inductor $L_1 = 0.5 \, H$, a capacitor $C_1 = 0.2 \, \mu F$ and a switch K. Assume that the capacitor voltage at $t = 0^-$ (just before the switch is closed) is $12V$. At $t = 662 \, \mu s$, the potential difference across the capacitor is:
   a) $12 \, V$
   b) $-12 \, V$
   c) $6 \, V$
   d) $-6 \, V$

2) As shown in the figure, a d.c. voltage $V$ is applied in the circuit. When the value of $R_2$ is halved,
   a) the current through $R_1$ increases.
   b) the current through $R_1$ stays the same.
   c) the voltage across $R_1$ decreases.
   d) the voltage across $R_1$ increases.

Questions 3 and 4 are linked questions:

A beam of monochromatic light ($\lambda = 640 \, \text{nm}$) impinges normally an opaque screen (P) having a narrow horizontal slit of width $0.4 \, \text{mm}$. The diffraction pattern is collected on a screen (E) $4 \, \text{m}$ from (P). M and O specify the position of the second dark fringe and the center of the bright central fringe, respectively.

3) The diffraction angle of the second dark fringe ($\theta = \theta$) is:
   a) $\theta = 0.00032 \, \text{rad}$
   b) $\theta = 0.0032 \, \text{rad}$
   c) $\theta = 0.032 \, \text{rad}$
   d) $\theta = 0.32 \, \text{rad}$

4) The distance OM is:
   a) $OM = 12.8 \, \text{nm}$
   b) $OM = 12.8 \, \text{mm}$
   c) $OM = 12.8 \, \text{cm}$
   d) $OM = 12.8 \, \text{m}$
Questions 5 to 8 are linked questions:

The spectrum of sodium-vapor lamp is dominated by the bright doublets (responsible for the bright yellow light) known as sodium D-lines at 589.0 nm and 589.6 nm. Other wavelengths of lights are also emitted, namely, \( \lambda_1 = 330.3 \text{ nm} \), \( \lambda_2 = 568.8 \text{ nm} \), \( \lambda_3 = 615.4 \text{ nm} \), \( \lambda_4 = 819.5 \text{ nm} \) and \( \lambda_5 = 1138.2 \text{ nm} \).

The figure below shows only the bright doublets of sodium spectrum.

![Sodium Spectrum Diagram](image)

Given, \( h = 6.62 \times 10^{-34} \text{ J.s} \); \( c = 3 \times 10^8 \text{ m/s} \); 1eV = 1.6\( \times \)10\(^{-19} \text{ J} \).

5) Which wavelengths among \( \lambda_1, \lambda_2, \lambda_3, \lambda_4 \) and \( \lambda_5 \) belong to the visible range?
   a) \( \lambda_1 \) et \( \lambda_2 \)
   b) \( \lambda_2 \) et \( \lambda_3 \)
   c) \( \lambda_3 \) et \( \lambda_4 \)
   d) \( \lambda_4 \) et \( \lambda_5 \)

6) Consider the yellow radiation of 589.0 nm wavelength. The photon energy corresponding to the emission of this radiation is approximately:
   a) 2.11 eV
   b) 3.76 eV
   c) 2.19 eV
   d) 1.09 eV

The following figure shows an energy level diagram for sodium.

7) The energy of the ground state is:
   a) 0 eV
   b) \(-1.94 \text{ eV}\)
   c) \(-3.03 \text{ eV}\)
   d) \(-5.14 \text{ eV}\)

8) The wavelength of the yellow radiation emitted by sodium corresponding to transition from an excited state to the ground state is 589.0 nm. Thus, the energy level of excited sodium will be:
   a) \( E_n = 0 \text{ eV} \)
   b) \( E_n = -1.94 \text{ eV} \)
   c) \( E_n = -3.03 \text{ eV} \)
   d) \( E_n = -5.14 \text{ eV} \)
Questions 9 to 12 are linked questions:

We would like to exploit a waveform and identify value of an unmarked device (D). (D) may be:
- a resistor $R_1$
- a capacitor $C$
- an ideal inductor $L$

For this purpose, we placed (D) in series with a resistor $R = 40 \, \Omega$ and a sinusoidal voltage

$$u_g = u_{AC} = 4 \, \sqrt{2} \cos(100 \, \pi t), \quad (u \text{ in V and } t \text{ in s})$$

An oscilloscope, properly connected, gives the waveform displaying voltages $u_{AC} = u_g$ of channel 1 and $u_{BC} = u_R$ of channel 2.

The vertical sensitivity of channel 2 is set to 2V/div.

9) The horizontal sensitivity is set to:
   a) $S_h = 2 \, \text{ms/div}$
   b) $S_h = 3 \, \text{ms/div}$
   c) $S_h = 5 \, \text{ms/div}$
   d) $S_h = 10 \, \text{ms/div}$

10) The device (D) is:
    a) a resistor.
    b) a capacitor.
    c) an inductor.
    d) unknown.

11) The relative phase between $u_{AC}$ and $u_{BC}$ is given by:
    a) $u_{BC}$ leads $u_{AC}$ by $\frac{\pi}{4} \text{ rad}$.
    b) $u_{BC}$ lags $u_{AC}$ by $\frac{\pi}{2} \text{ rad}$.
    c) $u_{BC}$ lags $u_{AC}$ by $\frac{\pi}{4} \text{ rad}$.
    d) $u_{BC}$ leads $u_{AC}$ by $\frac{\pi}{2} \text{ rad}$.

12) The value of maximum current $I_m$ is:
    a) $I_m = 0,05 \, \text{A}$
    b) $I_m = 0,1 \, \text{A}$
    c) $I_m = 0,15 \, \text{A}$
    d) $I_m = 0,2 \, \text{A}$
Consider a solid (S) of mass m attached to the end of a spring having a stiffness k, with the solid free to move on a frictionless, horizontal track CD. Assume that $x'Ox$ is the axis along which the centroid of solid G moves horizontally.

$\overline{OG}_0 = x_0 = -10 \text{ cm}$ is the position of G when the solid is displaced to the left of $x = 0$ (the equilibrium point). At $t_0 = 0$, the solid is released from position $G_0$.

13) The differential equation describing the motion of G at t is:
   a) $x'' - \frac{k}{m} x = 0$
   b) $x'' + \frac{m}{k} x = 0$
   c) $x'' + \frac{k}{m} x = 0$
   d) $x'' - \frac{m}{k} x = 0$

14) The values of the angular frequency $\omega_0$ (or natural frequency) and the period $T_0$ are:
   a) $\omega_0 = 6.32 \text{ rd/s}$ and $T_0 = 1 \text{ s}$
   b) $\omega_0 = 3.14 \text{ rd/s}$ and $T_0 = 2 \text{ s}$
   c) $\omega_0 = 1.57 \text{ rd/s}$ and $T_0 = 3 \text{ s}$
   d) $\omega_0 = 0.78 \text{ rd/s}$ and $T_0 = 4 \text{ s}$

15) The following cosine function $x = X_m \cos (\omega_0 t + \varphi)$ is a solution of the differential equation.
   The values of $X_m$ and the phase constant $\varphi$ are:
   a) $X_m = 0.1 \text{ m}$ et $\varphi = 0 \text{ rd}$
   b) $X_m = -0.1 \text{ m}$ et $\varphi = 0 \text{ rd}$
   c) $X_m = 0.1 \text{ m}$ et $\varphi = \pi \text{ rd}$
   d) $X_m = -0.1 \text{ m}$ et $\varphi = \pi \text{ rd}$

16) The extreme values of velocity $V$ are:
   a) $V = \pm 0.632 \text{ m/s}$
   b) $V = \pm 0.314 \text{ m/s}$
   c) $V = \pm 0.157 \text{ m/s}$
   d) $V = \pm 0.078 \text{ m/s}$

17) The total mechanical energy of system is:
   a) $E_m = 0.1 \text{ J}$
   b) $E_m = 0.2 \text{ J}$
   c) $E_m = 0.3 \text{ J}$
   d) $E_m = 0.4 \text{ J}$
Questions 18 to 20 are linked questions:

A 200-g body (S) slides down from rest a smooth plane inclined at $\alpha$ to the horizon. The center of mass G moves along $x'x$ axis parallel to the plane. The datum is located through $G_0$ at its initial position. 

(Take $g = 10 \text{ m/s}^2$)

The body (S) is released from rest at $t_0 = 0$. The table below depict the recorded positions of G at successive intervals of $\tau = 50 \text{ m/s}$.

<table>
<thead>
<tr>
<th>$t$ (s)</th>
<th>$t_0 = 0$</th>
<th>$t_1 = \tau$</th>
<th>$t_2 = 2\tau$</th>
<th>$t_3 = 3\tau$</th>
<th>$t_4 = 4\tau$</th>
<th>$t_5 = 5\tau$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$ (cm)</td>
<td>0</td>
<td>$G_0G_1 = 0.25$</td>
<td>$G_0G_2 = 1.00$</td>
<td>$G_0G_3 = 2.25$</td>
<td>$G_0G_4 = 4.00$</td>
<td>$G_0G_5 = 6.25$</td>
</tr>
</tbody>
</table>

18) The velocity of the body at $t_4 = 4\tau$ is:
   a) $V_4 = 0.4 \text{ m/s}$.  
   b) $V_4 = 0.8 \text{ m/s}$.  
   c) $V_4 = 0.2 \text{ m/s}$.  
   d) $V_4 = 1.0 \text{ m/s}$.  

19) The total mechanical energy of system at $t_4$ is:
   a) $E_{m4} = 0 \text{ J}$.  
   b) $E_{m4} = 0.016 \text{ J}$.  
   c) $E_{m4} = 0.32 \text{ J}$.  
   d) $E_{m4} = 1.6 \text{ J}$.  

20) The net force acting on the body is:
   a) $\Sigma \vec{F} = -Mg \cos \alpha \hat{i}$  
   b) $\Sigma \vec{F} = -Mg \sin \alpha \hat{i}$  
   c) $\Sigma \vec{F} = Mg \cos \alpha \hat{i}$  
   d) $\Sigma \vec{F} = Mg \sin \alpha \hat{i}$
Questions 21 to 25 are linked questions:

The fission of U-235 in reactors is triggered by the absorption of low energy neutron (0.025 eV), often termed a “slow neutron” or a “thermal neutron”. The equation for the nuclear fission is:

\[ ^{235}_{92}U + ^1_0n \rightarrow ^{\text{Sr}}_{94} + ^{\text{Xe}}_{\text{A}} + 3^{\text{n}}_0 \]

Given,

<table>
<thead>
<tr>
<th>Symbol</th>
<th>$^1_0n$</th>
<th>$^2_1H$</th>
<th>$^3_1H$</th>
<th>$^4_2He$</th>
<th>$^{235}_{92}U$</th>
<th>$^{94}_{\text{Sr}}$</th>
<th>$^{\text{Xe}}_{\text{A}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass (u)</td>
<td>1.00866</td>
<td>2.01355</td>
<td>3.01550</td>
<td>4.0015</td>
<td>234.9942</td>
<td>93.8945</td>
<td>138.8892</td>
</tr>
</tbody>
</table>

21) The values of A and Z are respectively:
   a) 139 et 38
   b) 38 et 139
   c) 138 et 39
   d) 39 et 138

22) The amount of energy produced is:
   a) E = 159.947 MeV.
   b) E = 169.947 MeV.
   c) E = 179.947 MeV.
   d) E = 189.947 MeV.

23) If each produced neutron has a average kinetic energy $E_0 = E/100$, identify which of the propositions are true:
   a) The number of nucleons in this reaction is 236.
   b) The produced energy per nucleon in the fission reaction is $E_1 = 0.76$ MeV/nucleon
   c) It should slow down the produced neutron to carry out the fission.
   d) All the propositions are true.

The fusion of deuterium $^2_1H$ with tritium $^3_1H$ create a neutron and an Hélium $^4_2He$.

24) The produced energy from this reaction is:
   a) $E' = 1.7596$ MeV.
   b) $E' = 17.596$ MeV.
   c) $E' = 175.96$ MeV.
   d) $E' = 1759.6$ MeV.

25) The produced energy per nucleon in the fusion reaction is:
   a) $E_{1'} = 3.5912$ MeV/nucleon
   b) $E_{1'} = 35.912$ MeV/nucleon
   c) $E_{1'} = 359.12$ MeV/nucleon
   d) $E_{1'} = 3591.2$ MeV/nucleon
Chemistry

20 questions - 20 points

1) A sample of 1.20 g of a powder mixture of iron and aluminum is treated with a solution of excess hydrochloric acid. When the reaction is ended, it has formed a volume of 710 mL of dihydrogen. Knowing $V_m = 24 \text{ L/mol}$ and Ox/Red couples: Fe$^{2+}$/Fe; Al$^{3+}$/Al; H$_3$O$^+$/H$_2$.

The mass percentage of iron in the mixture is:

a) 22%

b) 42%

c) 62%

d) 82%

2) 7.2 g of sodium benzoate C$_6$H$_5$COONa dissolved in 250 mL of distilled water. Then we mix 75 mL of the above solution and 25 mL of hydrochloric acid concentration of C = 0.050 mol/L. We don't consider the reaction of benzoate ion with water.

Given: $pK_A$ (C$_6$H$_5$COOH / C$_6$H$_5$COO$^-$) = 4.2; atomic molar mass (g/mol): $M_H = 1$; $M_C = 12$; $M_O = 16$; $M_{Na} = 23$.

The pH of the prepared solution is:

a) 3.2

b) 4.2

c) 5.2

d) 6.2

3) Two hydrochloric acid solutions S$_1$ and S$_2$ are respectively at the pH 1 and 2. We mix a volume $V_1$ of S$_1$ with a volume $V_2$ of S$_2$. In order to obtain a mixture solution of 500 mL with a pH of 1.3, we have to mix:

a) $V_1 = 111.11$ mL and $V_2 = 388.89$ mL.

b) $V_1 = 222.22$ mL and $V_2 = 277.78$ mL.

c) $V_1 = 333.33$ mL and $V_2 = 166.67$ mL.

d) $V_1 = 444.44$ mL and $V_2 = 55.56$ mL.

4) The Aspartame molecule whose structural formula is written above has:

HOOC–CH$_2$–CH–C–N–CH–CH$_2$–C$_6$H$_5$

||| |

H$_2$N O H COOCH$_3$

a) an alcohol and an acid functions.

b) anhydride, ester and alcohol functions.

c) acid, amine, amide and ester functions.

d) acide, ketone, amine and ester functions.

5) You can get soap by reaction between:

a) a carboxylic acid and an alcohol.

b) an acyl chloride and water.

c) an acid anhydride and water.

d) an ester and a strong base.
6) 2,5-Dimethylhexan-3-one is a ketone of formula:
   a) $C_8H_{10}O$
   b) $C_4H_{10}O$
   c) $C_8H_{16}O$
   d) $C_4H_9O$

**Questions 7 and 8 use the following statement:**

A hydrochloric acid solution reacts with zinc according to the following reaction:

$$2 \text{H}_3\text{O}^+ (aq) + \text{Zn} (s) \rightarrow \text{Zn}^{2+} (aq) + \text{H}_2 (g) + 2 \text{H}_2\text{O} (l).$$

**Given**
- Atomic molar mass: $M_{\text{Zn}} = 65.4 \text{ g.mol}^{-1}$.
- Molar volume of a gas under the conditions of the experiment: $V_m = 24 \text{ L.mol}^{-1}$.

At time $t = 0s$, we poured in a flask, containing 1 g of powder zinc, 40 mL of hydrochloric acid solution of concentration $C_a = 0.500 \text{ mol.L}^{-1}$. We consider the total volume of the reactive medium as constant.

The hydrogen gas formed during time was collected and its volume was measured.

7) At $t = \infty$, the concentration of Zn$^{2+}$ ions is given by:
   a) $[\text{Zn}^{2+}]_\infty = 0.10 \text{ mol.L}^{-1}$
   b) $[\text{Zn}^{2+}]_\infty = 0.15 \text{ mol.L}^{-1}$
   c) $[\text{Zn}^{2+}]_\infty = 0.20 \text{ mol.L}^{-1}$
   d) $[\text{Zn}^{2+}]_\infty = 0.25 \text{ mol.L}^{-1}$

8) The H$_3$O$^+$ concentrations, $[\text{H}_3\text{O}^+]_0$ at $t = 0$ and $[\text{H}_3\text{O}^+]_t$ at each instant $t$, are related to the volume of dihydrogen $V_{\text{H}_2}$ (expressed in mL), formed at each instant $t$, by the following relation:
   a) $[\text{H}_3\text{O}^+]_t = 2 \ [\text{H}_3\text{O}^+]_0 + \frac{V_{\text{H}_2}}{480}$
   b) $[\text{H}_3\text{O}^+]_t = [\text{H}_3\text{O}^+]_0 + \frac{V_{\text{H}_2}}{480}$
   c) $[\text{H}_3\text{O}^+]_t = 2 \ [\text{H}_3\text{O}^+]_0 - \frac{V_{\text{H}_2}}{480}$
   d) $[\text{H}_3\text{O}^+]_t = [\text{H}_3\text{O}^+]_0 - \frac{V_{\text{H}_2}}{480}$
Questions 9 to 12 use the following statement:

Some tests were performed on an unknown liquid organic compound (named A), the following results were obtained:
- an aqueous solution of A does not lead the electric current;
- A reacts with the sodium metal and produces dihydrogen gas
- a catalytic dehydrogenation of A leads to an organic compound (called B) which gave a yellow precipitate with 2,4-DNPH

Given:
- Density of A : \( \mu = 0.81 \text{ g.mL}^{-1} \).
- Atomic molar mass (g/mol): \( M_H = 1; \ M_C = 12; \ M_O = 16; \ M_Cl = 35.5. \)

9) Based on the results of the three previous tests, we conclude that the chemical family of A is :
   a) an acid.
   b) a base.
   c) an alcohol.
   d) not defined.

10) A contains a saturated and not cyclic hydrocarbon chain with n carbon atoms length, Guess the molecular formula of A:
   a) \( C_nH_{2n+1}OH \)
   b) \( C_nH_{2n}OH \)
   c) \( C_nH_{2n+1} \)
   d) \( C_nH_{2n} \)

11) A volume of 9.1 mL of A is reacted with an excess of SOCl\(_2\) according the following reaction:
    \[ A + SOCl_2 \rightarrow R – Cl + SO_2 + HCl \]
    We obtain 9.2 g of the organic compound (R – Cl). The molecular formula of is:
   a) \( C_4H_{10}O \)
   b) \( C_4H_9O \)
   c) \( C_4H_{10} \)
   d) \( C_4H_9 \)

12) The compound "A" has:
   a) 1 possible semi-structural formula.
   b) 2 possible semi-structural formulas.
   c) 3 possible semi-structural formulas.
   d) 4 possible semi-structural formulas.
Questions 13 to 17 use the following statement:

We have available a flask whose labels bear the following indication:

*Acid (A) of formula: R-COOH.*

In the aim to identify the contents of the flask, the dehydration of 1.48 g of (A) is carried out in the presence of P₂O₅ (dehydrating agent), this leads to the formation of the anhydride acid (A) and 0.01 mol of H₂O.

Given: Atomic molar mass (g/mol): \( M_{(H)} = 1, M_{(C)} = 12, M_{(O)} = 16. \)

13) The dehydration reaction of the acid (A) can be written:
   a) \( 2 \text{R–COOH} \rightarrow 2 \text{R–CO}_2 + 1/2 \text{H}_2\text{O} \)
   b) \( 2 \text{R–COOH} \rightarrow (\text{R–CO})_2\text{O} + \text{H}_2\text{O} \)
   c) \( 3 \text{R–COOH} \rightarrow (\text{R–CO})_3\text{O} + 3/2 \text{H}_2\text{O} \)
   d) \( 2 \text{R–COOH} \rightarrow (\text{R–CO})_2\text{O} + 1/2 \text{H}_2\text{O} \)

14) The number of moles of (A) is:
   a) 0.02 mol
   b) 0.03 mol
   c) 0.04 mol
   d) 0.05 mol

15) The molar mass of (A) is:
   a) 62 g.mol⁻¹
   b) 66 g.mol⁻¹
   c) 70 g.mol⁻¹
   d) 74 g.mol⁻¹

16) If R is an alkyl group, the molecular formula of (A) is:
   a) \( \text{C}_2\text{H}_4\text{O}_2 \)
   b) \( \text{C}_2\text{H}_6\text{O}_2 \)
   c) \( \text{C}_3\text{H}_6\text{O}_2 \)
   d) \( \text{C}_3\text{H}_5\text{O}_2 \)

17) The flask contains the following product is:
   a) the butanoic acid.
   b) the acetic acid.
   c) the propanoic acid
   d) the ethanedioic acid.
Questions 18 to 20 use the following statement:

The structures of the available organic compounds are listed in the following table:

<table>
<thead>
<tr>
<th>Compounds</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-structural formula</td>
<td>CH₃ – CO₡H</td>
<td>CH₃ – CH₂ – CH – OH</td>
<td>NH₂ – CH₂ – CO₡H</td>
</tr>
</tbody>
</table>

18) «2-aminoethanoic acid » is the systematic name of:
   a) compound A.
   b) compound B.
   c) compound C.
   d) none of the given organic compounds.

19) « butan-2-ol » is the systematic name of:
   a) compound A.
   b) compound B.
   c) compound C.
   d) none of the given organic compounds.

20) Among the given organic compounds, the chiral specie is:
   a) the compound A.
   b) the compound B.
   c) the compound C.
   d) not any.
General Knowledge
30 questions - 10 points

1. The famous painting "Mona Lisa" is exposed at the:
   a) Louvre museum in Paris.
   b) British Museum in London.
   c) National Museum in Cairo.

2. Who composed the symphony "Ode to Joy"?
   a) Beethoven.
   b) Rachmaninov.
   c) Vivaldi.
   d) Mozart.

3. "I think therefore I am" is a quote of:
   a) Descartes.
   b) Einstein.
   c) Rutherford.
   d) Pascal.

4. "It is easier to break an atom than a prejudice" is a quote of:
   a) Descartes.
   b) Einstein.
   c) Rutherford.
   d) Pascal.

5. Who discovered penicillin?
   a) Alexander Fleming.
   b) Louis Pasteur.
   c) Alfred Nobel.
   d) Marie Curie.

6. Who discovered the theory of relativity?
   a) Plank.
   b) Einstein.
   c) Rutherford.
   d) De Broglie.

7. Who invented the electric battery?
   a) Watt.
   b) Volta.
   c) Ampere.
   d) Joules.
8. Who invented the telescope?
   a) Galilee.
   b) Archimedes.
   c) Newton.
   d) Thales.

9. Who discovered the law of universal gravitation?
   a) Galilee.
   b) Archimedes.
   c) Newton.
   d) Thales.

10. The first man who walked on the Moon is:
    a) Yuri Gagarin.
    b) Neil Armstrong.
    c) Yuri Artioukhine.
    d) Alan Shepard.

11. The first man to have flown in space is:
    a) Yuri Gagarin.
    b) Neil Armstrong.
    c) Yuri Artioukhine.
    d) Alan Shepard.

12. According to the theory of the Big Bang, the universe is:
    a) 1 billion years old.
    b) 15 billion years old.
    c) 50 billion years old.
    d) 100 billion years old.

13. The most abundant element in the universe is:
    a) Carbon.
    b) Helium.
    c) Hydrogen.
    d) Oxygen.

14. What is the biggest planet in the solar system?
    a) Mercury.
    b) Saturn.
    c) Neptune.
    d) Jupiter.

15. The sound is not transmitted through:
    a) vacuum.
    b) metal.
    c) liquids.
    d) cotton.
16. A light year is:
   a) A unit of distance.
   b) An approximate duration.
   c) A unit of time.
   d) A measurement of brightness.

17. The Beaufort scale is used to measure:
   a) The quality of the air.
   b) The strength of the wind.
   c) The energy released by an earthquake.
   d) The height of Tsunami waves.

18. The Richter scale is used to measure:
   a) The quality of the air.
   b) The strength of the wind.
   c) The energy released by an earthquake.
   d) The height of Tsunami waves.

19. Among these names, which does not refer to a cloud?
   a) Cumulus.
   b) Stratus.
   c) Altus.
   d) Cirrus.

20. UNESCO is an international institution which deals with:
   a) world health problems.
   b) education, science and culture.
   c) peace in the world.
   d) starvation in Africa.

21. How many squares have a chessboard?
   a) 49.
   b) 64.
   c) 81.
   d) 100.

22. Mark Zuckerberg is one of the founders of:
   a) Twitter.
   b) Facebook.
   c) Google.
   d) Yahoo.

23. What is the capital of India?
   a) Kathmandu.
   b) Calcutta.
   c) New Delhi.
   d) Bombay.
24. Among these countries, which has not adopted the Euro?
   a) Germany
   b) England
   c) Italy
   d) Spain

25. Which of these countries is not in Europe?
   a) Estonia.
   b) Armenia.
   c) Sweden.
   d) Montenegro.

26. The battlefield of Waterloo is located in:
   a) Germany.
   b) Austria.
   c) France.
   d) Belgium.

27. How do you write 2013 in Roman numerals?
   a) MMXIII
   b) MMVIII
   c) MDXIII
   d) MDVIII

28. Lebanon gained independence in:
   a) 1941
   b) 1942
   c) 1943
   d) 1944

29. The first prime minister after independence of Lebanon was:
   a) Riad El Solh.
   b) Bechara El Khoury.
   c) Adel Oseyrane.
   d) Sabri Hamadeh.

30. Since 2003, Lebanon is divided into:
   a) 5 governorates
   b) 6 governorates
   c) 7 governorates
   d) 8 governorates