SOUTH AFRICAN AGENCY FOR SCIENCE AND TECHNOLOGY ADVANCEMENT

PHYSICS OLYMPIAD

GRADE 10 - 12

2020

INSTRUCTIONS

Please read the instructions carefully before answering the questions

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This is a multiple choice paper. Please answer all the questions on the answer sheet provided. Each question is followed by answers marked A, B, C, and D. **Only one answer is correct**. Choose the correct answer and shade the corresponding circle on the answer sheet completely, using an HB pencil.

NB! The answer sheets are marked electronically – do not make any other dots or marks on the answer sheet. Select only one answer for each question or your answer will be discarded**. Ensure that you shade your selection clearly.**

Note that the question numbers 1 to 100 on the answer sheet moves from top to bottom in several columns. Ensure that the number of your selection on the answer sheet corresponds with the number of the question in your examination paper. Should you make a mistake, please erase the incorrect answer completely

The use of **non-programmable** electronic calculators is permitted.

To avoid disqualification - You are required to complete **all** the information requested on the answer sheet. Please complete the information in script, as well as shade the corresponding blocks. If the corresponding blocks are not shaded appropriately, your results will be returned without a name and you will be disqualified. Do not fold the answer sheets.

This paper consists of 15 pages and 5 data sheets.

Three hours are allowed to answer the questions

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1. **Consider the following equation for a chemical reaction taking place in acid medium:**

$$MnO_4^- + H_2SO_3 \rightarrow SO_4^{2-} + Mn^{2+},$$

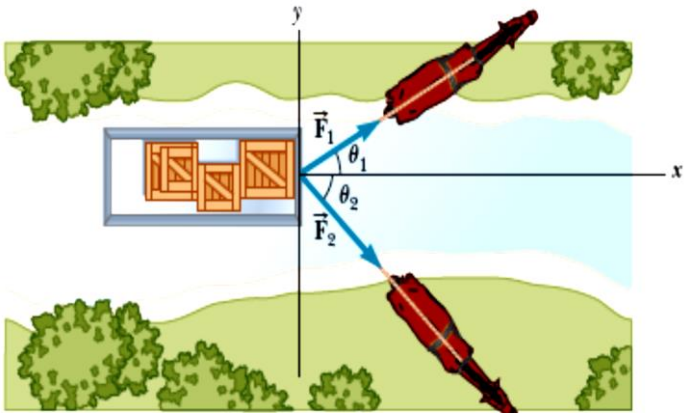
Which one of the following optionsrepresents a balanced equation for this reaction?

A. $MnO_4^- + H_2SO_3 \rightarrow SO_4^{2-} + Mn^{2+}$
B. $2MnO_4^- + 4H_2SO_3 \rightarrow 5SO_4^{2-} + 2Mn^{2+}$
C. $2MnO_4^- + 5H_2SO_3 \rightarrow 2Mn^{2+} + 3H_2O + 5SO_4^{2-} + 4H^+$
D. This equation is incomplete therefore we can't balance the equation of this reaction.

2. **Using your microwave oven, how many moles of photons are needed to heat your cup of tea? Consider a cup of tea to be 237 mL of water starting at 25.0 °C and the drinking temperature to be a warm 85.5 °C. Also, most microwave ovens have Klystron tubes tuned to emit microwaves that are absorbed by water molecules at a wavelength of 12.24 cm.**

A. 6.14×10^4 mol photons
B. 1.623×10^{-24} mol photons
C. 3 696 10^{28} mol photons
D. We can't calculate number of moles of photons

3. **Two horses are pulling a barge with mass $2000\ kg$ along a canal. The cable connected to the first horse makes an angle of $\theta_1 = 30.0^0$ with respect to the direction of the canal, while the cable connected to the second horse makes an angle of $\theta_2 = -45.0^0$. Calculate the initial acceleration of the barge, starting at rest, if each horse exerts a force of magnitude $600N$ on the barge. Ignore forces of resistance on the barge.**



A. $a = 0.476\ m.s^{-2}$
B. $a = -0.476\ m.s^{-2}$
C. $a = 0.476\ m.s^{-2}; \theta = -7.46^0$
D. $a = 0.476\ m.s^{-2}; \theta = 7.46^0$

4. **A car with a mass of 1500 kg is being towed by a rope held at a 20° angle to the horizontal. A friction force of 320 N opposes the car's motion. What is the tension in the rope if the car goes from rest to 12 m/s in 10 s?**

A. 1500N
B. 1180N
C. 3200N
D. None of the above

5. **Sodium hydroxide granules can remove carbon dioxide from an airstream by its reaction, according to the following equation:**

$$NaOH_{(s)} + CO_{2(g)} \rightarrow NaHCO_{3(s)}$$

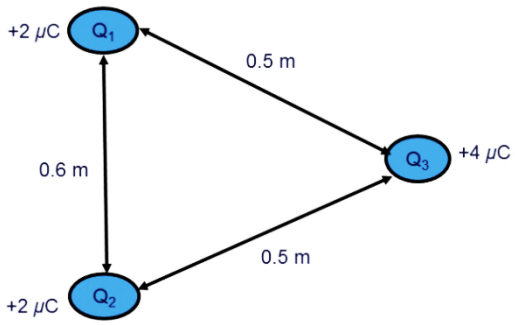
The air of a room measuring $5.00\ m \times 10.00\ m \times 3.50\ m$ containing CO_2 at a concentration of $1.00 \times 10^{-6} mol.dm^{-3}$ is passed through a bed of $NaOH$ granules. Calculate the minimum number of grams of $NaOH$ needed to remove all of the CO_2 from this quantity of air?

A. 1.75 g
B. 17.5 g
C. 70.0 g
D. 7.00 g

6. **A chemist set up a synthesis of phosphorus trichloride by mixing 12.0 g of phosphorus with 35.0 g of chlorine gas and obtained 42.4 g of solid phosphorus trichloride. Assist the chemist in selecting the percentage yield of this compound below:**

A. 91.2%
B. 93.8%
C. 117.7%
D. 85.0%

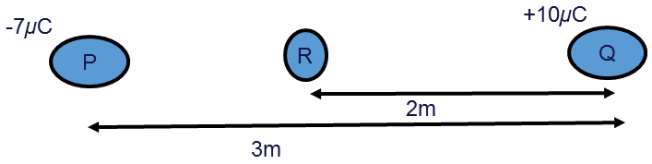
7. **Two equal positive charges, Q_1 and Q_2, each carrying a charge of 2 µC, interact with a third charge, Q_3, carrying a charge of 4 µC. Suppose Q_1 and Q_2 are placed 0,6 m away from each other and charge Q_3 is placed 0.5 m away from both Q_1 and Q_2, as shown in the figure below.**



What will the magnitude and direction of the resultant electrostatic force on Q_3 be?

A. 0.29 N
B. 0.23 N
C. -0.17 N
D. 0.46 N

8. **Two point charges, P and Q, with a distance of 3 m apart are shown below. The charge on P is - 7 µC and the charge on Q is +10 µC.**



Calculate the net electric field strength at point R situated 2m from Q:

A) 85 500 $N.C^{-1}$ to the left
B) 40 500 $N.C^{-1}$ to the right
C) 171 000 $N.C^{-1}$ to the left
D) 153 000 $N.C^{-1}$ to the left

9. **Tungsten wire is the filament inside most incandescent lightbulbs. In a typical lightbulb, the tungsten filament weighs 0.635 grams. How many atoms of tungsten are there in such a lightbulb filament?**

A. 2.08 $x10^{21}$ atoms W
B. 2.08 $x10^{23}$ atoms W
C. 3.82 $x10^{23}$ atoms W
D. 3.28 $x10^{21}$ atoms W

10. **Chlorophyll, the green pigment in leaves, has the formula $C_{55}H_{72}MgN_4O_5$. If 0.0011 g of Mg is available to a plant for chlorophyll synthesis, from the options given below, identify the mass of carbon that will be required to completely use up the magnesium?**

A. 0.0011g of C
B. 0.0605g of C
C. 0.0300g of C
D. None of the Above

11. **A furniture truck is moving along a level road at constant velocity. An object drops from the mid-point of the ceiling inside the truck. Where on the floor will the object land?**

A. Ahead of the point exactly below the mid-point of the ceiling
B. Behind the point exactly below the mid-point of the ceiling
C. Exactly on the point below the mid-point of the ceiling
D. One cannot say without knowing the value of the velocity of the truck

12. **Three resistors of 12 Ω are used in different combinations in series, parallel and mixed. Which of the following values cannot represent the total resistance of the combination when the three resistors are used?**

A) 18
B) 48
C) 36
D) 4

13. **Milk of magnesia is a suspension of $Mg(OH)_2$ in water. It can be made by adding a base to a solution containing Mg^{2+}. Suppose that 40.0 mL of 0.200 *mol.dm^{-3}* NaOH solution is added to 25.0 mL of 0.300 mol.dm^{-3} $MgCl_2$ solution. From the four options below select the mass of $Mg(OH)_2$ that will be formed, and the concentrations of the ions in the solution after the reaction is complete?**

A. 0.466g $Mg(OH)_2$ and 3.50x 10^{-3} mol.dm^{-3} Mg^{2+}
B. 0.466g $Mg(OH)_2$ and 0.0538 mol.dm^{-3} Mg^{2+}
C. 0.233g $Mg(OH)_2$ and 0.0538 mol.dm^{-3} Mg^{2+}
D. 0.233g $Mg(OH)_2$ and 0.1230 mol.dm^{-3} Mg^{2+}

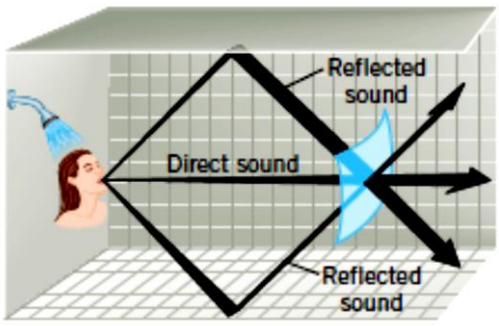
14. **All the iron in a 2.00 g sample of an iron ore was dissolved in an acidic solution and converted to Fe^{2+}, which was then titrated with 0.100 *mol.dm^{-3}* $KMnO_4$ solution. In the titration the iron was oxidized to Fe^{3+}. The titration required 27.45 mL of the $KMnO_4$ solution to reach the end point. If the iron was present in the sample as Fe_2O_3, what was the percentage by mass of Fe_2O_3 in the sample?**

A. 54.7% Fe_2O_3
B. 38.3% Fe_2O_3
C. 61.7% Fe_2O_3
D. 41.6% Fe_2O_3

15. **A projectile will attain its maximum range, if it is fired at an angle of**

A. 45°
B. 30°
C. 47°
D. 90°

16. **Suppose that the person singing in the shower in the figure below produces a sound power P.**



Sound reflects from the surrounding shower stall. At a distance r in front of the person, the expression $I = {}^{P}/_{(4\pi r^2)}$

A. Overestimates the total sound intensity
B. Underestimates the total sound intensity
C. Gives the correct total sound intensity
D. Is not related to the total sound intensity

17. **For an object moving in uniform circular motion, the direction of the instantaneous acceleration vector is:**

A. tangent to the path of motion
B. equal to zero
C. directed radially outward
D. directed radially inward

18. **A bottle of red wine is thought to have been sealed about 5 years ago. The wine contains a number of different atoms, including carbon, oxygen, and hydrogen. Each of these has a radioactive isotope. The radioactive isotope of carbon is the familiar $^{14}_{6}C$, with a half-life of 5730 yr. The radioactive isotope of oxygen is $^{15}_{8}O$ and has a half-life of 122.2 s. The radioactive isotope of hydrogen, called tritium, is $^{3}_{1}H$; its half-life is 12.33 yr. The activity of each of these isotopes is known at the time the bottle was sealed. However, only one of the isotopes is useful for determining the age of the wine accurately from a measurement of its current activity. Which is it?**

A. $^{14}_{6}C$
B. $^{15}_{8}O$
C. $^{3}_{1}H$
D. The isotope is not mentioned on the list

19. **The working principle of a washing machine is**

A. reverse osmosis
B. diffusion
C. centrifugation
D. dialysis

20. Methane, CH_4, is a tetrahedral molecule. How is this explained in terms of valence bond theory?

A. sp^3 Hybridized
B. sp^2 Hybridized
C. sp Hybridized
D. You only need Lewis diagrams of the molecule to be able to decide the shape of the molecules according to VSEPR. (Hybridization is NOT needed.)

21. What is the pH of a 0.11 $mol.dm^{-3}$ solution of Na_2CO_3?
(Hint: For CO_3^{2-}, $K_{b1} = 1.8 \times 10^{-4}$)

A. 10.96
B. 11.64
C. 12.36
D. 13.04

22. For which of the following molecules does octet theory work?

A. PF_5
B. NO
C. $[PtCl_2(NH_3)_2]$
D. N_2

23. Three substances X, Y and Z_2 are mixed. The reaction which takes place occurs in two steps:

I $\quad X + Z_2 \rightarrow XZ_2$

II $\quad Y + XZ_2 \rightarrow X + YZ_2$

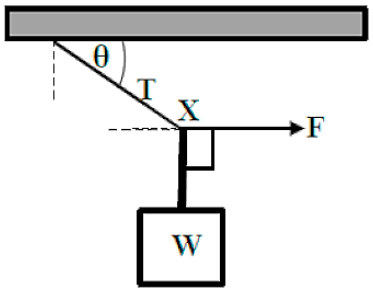
Which one of the following substances acted as a catalyst in the above reactions?

A. X
B. Y
C XZ_2
D. Z_2

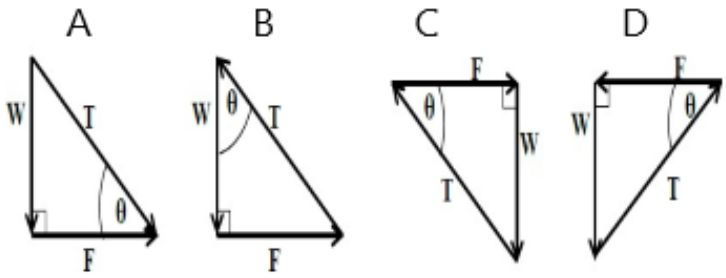
24. A thermal neutron has a relatively small amount of kinetic energy but, nevertheless, can penetrate a nucleus. To penetrate the same nucleus, a proton or an α particle will need ...

A. the same small amount of kinetic energy as the neutron needs.
B. a much larger amount of kinetic energy than the neutron needs.
C. much less kinetic energy than the neutron needs.
D. none of the above.

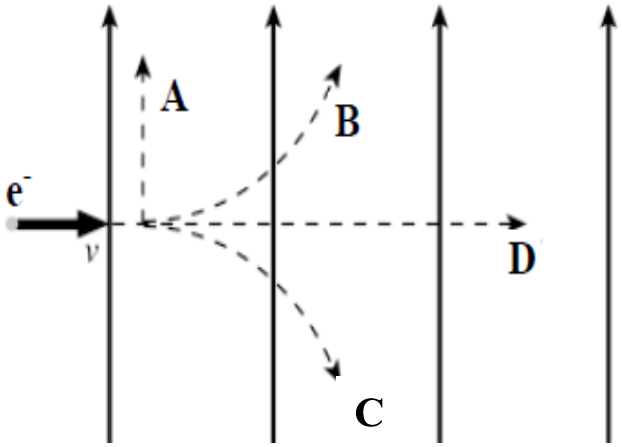
25. A weight W is suspended from a light string and is pulled sideways by a force F, which acts horizontally to point X of the string. The system is in equilibrium when the angle between the string and the horizontal is θ as shown in the diagram. The tension in the string is T.



Which one of the following diagrams is the correct force triangle for this system?



26. An electron initially moves to the right when it enters a uniform electric field directed upwards. Study or analyse the paths shown in the diagram below and choose the path which the electron will follow.



27. The distance between an asteroid and a comet is 1000 km. The gravitational force between these bodies is F newton. After a few days, the comet has lost a tenth of its mass and is now 750 km away from the asteroid. Calculate the new gravitational force in terms of F Newton?

A. 0,13 $\boldsymbol{F}$
B. 0,18 $\boldsymbol{F}$
C. 1,20 $\boldsymbol{F}$
D. 1,60 $\boldsymbol{F}$

28. The bright light produced by the reaction between magnesium and oxygen is often used in fireworks displays. The product of the reaction is magnesium oxide, an ionic compound. In the reaction:...

A. Is oxygen a reducing agent and magnesium is an oxidising agent
B. Oxygen is reduced and magnesium is oxidised
C. Both magnesium and oxygen are oxidised
D. Both magnesium and oxygen were reduced

29. What happens when a potassium phosphate (K_3PO_4) solution is mixed with a calcium nitrate [$Ca(NO_3)_2$] solution.

A. Calcium ions (Ca^{-2}) and phosphate ions (PO_4^{-3}) will form a soluble compound, calcium phosphate [$Ca_3(PO_4)^2$], while the other soluble product is KNO_3. Therefore, this is an ion-exchange reaction.
B. Calcium ions (Ca^{-2}) and phosphate ions (PO_4^{-3}) will form an insoluble compound, calcium phosphate [$Ca_3(PO_4)^2$], while the other product, KNO_3, is soluble and remains in solution. Therefore, this is a precipitation reaction.
C. Calcium ions (Ca^{-2}) and phosphate ions (PO_4^{-3}) will form a soluble compound, calcium phosphate [$Ca_3(PO_4)^2$], while the other product, KNO_3, is insoluble and remains in solution. Therefore, this is a precipitation reaction.
D. No reaction takes place

30. Xenon is one of the noble gases, and is generally quite unreactive. In fact, it was long believed that all the noble gases were totally unable to form compounds. It came as quite a surprise, therefore, when it was discovered that some compounds could be made. One of these is xenon difluoride. What would you assume the geometry of xenon difluoride to be?

A. Trigonal bipyramid
B. Tetrahedral
C. Non-Linear
D. Linear

31. When a lamp is connected to a 240 V source, the power dissipated is P. The same lamp is now connected to a 120 V source. Assume that the resistance of the lamp remains constant. The power dissipation will now be equal to:

A. 0
B. $\frac{1}{4}\boldsymbol{P}$
C. $\frac{1}{2}\boldsymbol{P}$
D. $\boldsymbol{P}$

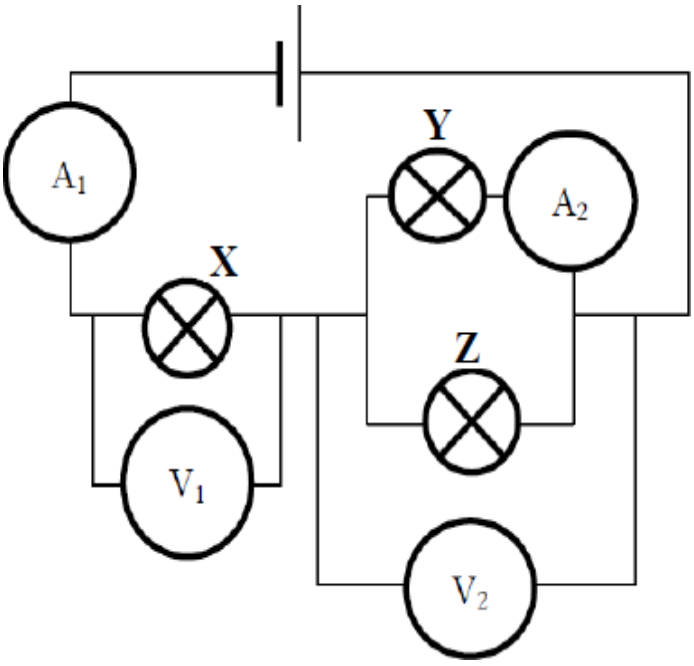
32. A ball of mass m is thrown towards a wall with speed v and it rebounds with the same speed v. If the force that the wall exerts on the ball during the collision is F, how long did the collision last?

A. $\frac{F}{mv}$
B. $\frac{F}{2mv}$
C. $\frac{mv}{F}$
D. $\frac{2mv}{F}$

33. NASA launches a rocket from Cape Canaveral. By the time the rocket reaches a height of twice the Earth's radius above the surface, it has lost half of its mass due to the usage of rocket fuel. If the magnitude of the weight of the rocket on the Earth's surface is W, what is the new weight at this height?

A. $\frac{W}{18}$
B. $\frac{W}{6}$
C. $\frac{2W}{3}$
D. $\frac{2W}{9}$

34. In the circuit diagram below, the bulbs are all identical. The resistances of the ammeters, connecting wires and the cell are negligible.



Which one of the following correctly gives the ratio of the power dissipated in bulb X (P_X) to the power dissipated in bulb Y (P_Y)?

A. 4:1
B. 1:4
C. 2:1
D. 1:2

35. At a certain temperature, K_c = 4.50 for the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$. If 0.300 mol of N_2O_4 is placed into a 2.00 L container at this temperature, what will the equilibrium concentrations of each of the gases be?

A. $[N_2O_4]$ = 1.110 mol.dm^{-3} and $[NO_2]$ = 0.268 mol.dm^{-3}
B. $[N_2O_4]$ = 1.410 mol.dm^{-3} and $[NO_2]$ = 2.520 mol.dm^{-3}
C. $[N_2O_4]$ = 0.016 mol.dm^{-3} and $[NO_2]$ = 2.520 mol.dm^{-3}
D. $[N_2O_4]$ = 0.016 mol.dm^{-3} and $[NO_2]$ = 0.268 mol.dm^{-3}

36. First year Chemistry students at the University of Limpopo Turfloop campus are given laboratory instructions to prepare the following endothermic reaction:

$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$ with $K_c = 5.67$ at 1500 °C.

Their task is to investigate whether the amount of $CO_{(g)}$ at equilibrium will be affected or not by:

(i) adding more $H_2O_{(g)}$,
(ii) lowering the pressure by increasing the volume of the container,
(iii) raising the temperature of the reaction mixture, and
(iv) adding a catalyst to the system

Predict the effects of various changes on the amount of $CO_{(g)}$ at equilibrium and in which direction will K_c change?

	(i)	(ii)	(iii)	(iv)	K_c
A.	Increase	Increase	Increase	Increase	No change
B.	Increase	Decrease	Increase	No change	Will not change with addition of a catalyst
C.	Increase	Increase	Increase	No change	Will increase with an increase in temperature
D.	Increase	Increase	Increase	Increase	Will increase with an increase in temperature

37. A galvanic cell is constructed by placing 1.0 mol.dm^{-3} aluminium nitrate in one beaker with an aluminium electrode and a second beaker with 1.0 mol.dm^{-3} copper nitrate and a copper electrode. When a salt bridge is inserted to connect the two beakers, calculate the cell potential that we expect to measure between the copper and aluminium electrodes?

A. 1.32 V
B. 2.00V
C. -1.32 V
D. 0.00 V

38. A current of 1.26 A is passed through an electrolytic cell containing a dilute sulphuric acid solution for 7.44 h. Calculate the volume of gases generated at STP.

A. 22.4 dm^3 O_2 and 22.4 dm^3 H_2 at STP
B. 1.96 dm^3 O_2 and 3.92 dm^3 H_2 at STP
C. 3.92 dm^3 O_2 and 1.96 dm^3 H_2 at STP
D. None of the above

39. Calculate the cost to run a 900 W microwave oven for 2.5 minutes if the cost of electricity is 61,6 c per kWh?

A) 3,75c
B) 2,31 c
C) 2,50 c
D) 13,86 c

40. In 2015, the world's population totaled nearly 7.5 billion people. What proportion of these did not have access to reliable, affordable mains electricity?

A. Over 20%
B. About 13%
C. About 5%
D. About 20%.

41. By 2035, global CO_2 emissions must fall to what proportion of the current level to limit the global temperature rise to 2°C above pre-industrial levels?

A. 70%
B. 60%
C. 50%
D. 40%.

42. Calcium phosphate is widely found in nature in the form of natural minerals. It is also found in bones and some kidney stones. In one case a sample is found to contain 0.864 moles of phosphorus. How many moles of $Ca_3(PO_4)_2$ are in that sample?

A. 0.432 moles
B. 0.576 moles
C. 0.864 moles
D. 1.728 moles

43. A 0.5438 g sample of a pure liquid consisting of only C, H, and O was burned in 100% oxygen, and 1.039 g of CO_2 and 0.6369 g of H_2O were obtained. What is the empirical formula of the compound?

A. $C_6H_{12}O_6$
B. $C_xH_yO_z$
C. $C_{12}H_{22}O_{11}$
D. C_2H_6O

44. During a practical session, a Tshwane University of Technology student, Zinzi's experimental analysis found that the sulphate ion concentration in a solution of $Al_2(SO_4)_3$ was 0.90 mol.dm^{-3}. Use dimensional analysis to help Zinzi to find the concentration of $Al_2(SO_4)_3$ in the solution?

A. 0.09 mol.dm^{-3}
B. 0.06mol.dm^{-3}
C. 0.03 mol.dm^{-3}
D. 0.01 mol.dm^{-3}

45. What reaction (if any) occurs in water between potassium nitrate and ammonium chloride?

A. $KNO_3 + NH_4Cl \rightarrow KCl + NH_4NO_3$
B. $KNO_3 + NH_4Cl \rightarrow KCl + N_2O + H_2O$
C. No net reaction
D. None of the above

46. A radar that is used to detect the presence of an enemy aircraft uses:

A. Sound waves
B. Radio waves
C. Electric waves
D. Ultrasonic waves

47. What is the weight of an object that can be lifted with a lever that requires an input force of 15 N and has a mechanical advantage of 2.33?

A. 0.16 N
B. 34.95 N
C. 6.44 N
D. 20 N

48. Which electronic component releases light of a specific frequency when current passes through it in one direction, but does not release any light if the current direction is reversed?

A. Compact fluorescent bulb
B. Laser
C. Light Emitting Diode
D. Thermionic Diode

49. Different colours of different stars are due to variation of

A. Temperature
B. Density
C. Pressure
D. Radiation from them

50. In a refrigerator, what produces the cooling?

A. The ice which deposits on the freezer
B. The sudden expansion of a compressed gas
C. The evaporation of volatile liquid
D. None of these

51. What is dark matter?

A. Matter that emits no radiation
B. Luminous matter
C. Black matter
D. Clear matter

52. Which Einstein theory established that nothing can travel faster than light?

A. Special relativity
B. General relativity
C. The Big Bang theory
D. Quantum relativity

53. When a rifle is fired the gunpowder in the shell is ignited, the bullet is ejected and the rifle recoils. Which one of the following is directly responsible for the recoil?

A. The pressure of the gases on the front of the bullet.
B. The pressure of the hot gases on the rear of the bullet.
C. The force of the bullet on the outside air.
D. The friction between the bullet and the inside surface of the barrel.

54. Compare the following methods below and decide on the one that is NOT a method of producing hydrogen:

A. Electrolysis of water
B. Fermentation of sugar
C. Steam reforming of natural gas
D. Thermal dissociation of water

55. Point out a molecule that is hypervalent below

A. CF_4
B. SF_4
C. BF_3
D. NF_3

56. Which of these processes is used to produce biomethane from dung, sewage or food processing wastes?

A. Anaerobic digestion
B. Fermentation
C. Transesterification
D. None of the above

57. Outline the structure at the Te in $TeBr_6^{2-}$

A. A pentagonal bipyramid
B. A capped octahedron
C. An octahedron with a stereochemically inert pair of electrons
D. Trigonal bipyramid.

58. What are radioisotopes that are used for medical diagnosis called?

A. Tracers
B. Markers
C. Dyes
D. Silver decks

59. Which type of radiation is the least penetrating?

A. Gamma
B. X-ray
C. Beta
D. Alpha

60. Estimate the heat of reaction at 298 K for the reaction shown, given the average bond energies provided in the table below.

$Br_2(g) + 3F_2(g) \rightarrow 2BrF_3(g)$

Bond	Bond Energy
Br-Br	192 kJ
F-F	158 kJ
Br-F	197 kJ

A. -75 kJ
B. -516 kJ
C. -153 kJ
D. -272 kJ

61. Name the family to which the compound $CH_3CH_2CH_2NH_2$ belongs

A. Amide
B. Amine
C. Nitrile
D. Ester

62. JJ Thomson discovered which fundamental particle?

A. Proton
B. Electron
C. Atom
D. Neutron

63. An intergalactic cruiser approaches a hostile spacecraft. Both vehicles move at a constant velocity. The velocity of the cruiser relative to the spacecraft is $v_{CS} = +0.7c$, the direction to the right being the positive direction. The cruiser fires a beam of laser light at the hostile renegades. The velocity of the laser beam relative to the cruiser is $v_{LC} = +c$.

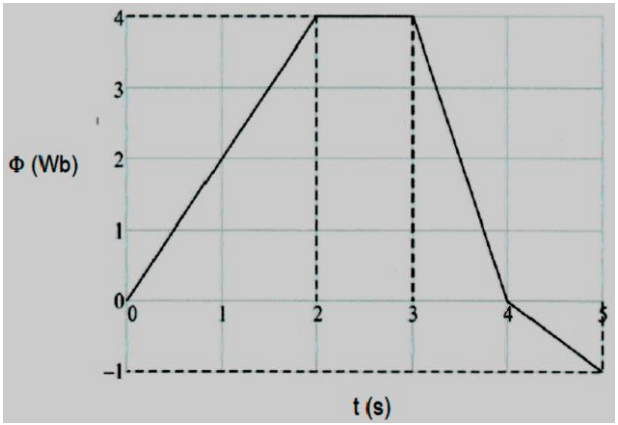
Which one of the following statements correctly describes the velocity v_{LS} of the laser beam relative to the renegades' spacecraft and the velocity v at which the renegades see the laser beam move away from the cruiser?

A. $v_{LS} = +0.7c \; and \; v = +c$
B. $v_{LS} = +0.3c \; and \; v = +c$
C. $v_{LS} = +c \; and \; v = +0.7c$
D. $v_{LS} = +c \; and \; v = +0.3c$

64. The combined ideal gas equation can only be used when the_____of the gas remains constant.

A. volume
B. mass
C. pressure
D. none of the above

65. The magnetic flux passing through a coil of wire changes as shown in the graph below. Demonstrate the time interval where the induced emf in the coil will be a minimum.

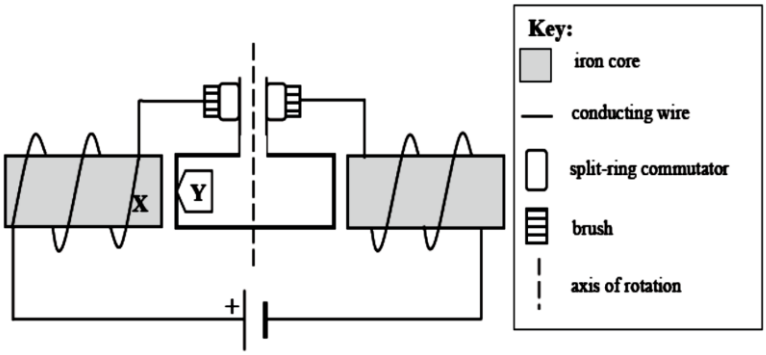


A. 0 s – 0,2 s
B. 2 s – 3 s
C. 3 s – 4 s
D. 4 s – 5 s

66. The potential difference across a resistor is 12 V. The current in the resistor is 2.0 A and and a charge of 4.0 C passes through the resistor. Calculate the energy that will be transferred and also calculate the time taken?

	Energy (J)	Time (s)
A.	3,0	2,0
B.	3,0	8,0
C.	48,0	2,0
D.	48,0	8,0

67. Refer to the following diagram showing a simple DC electric motor in cross section:



What is the polarity of the electromagnet at **X** and the direction of motion of the wire at **Y**?

	Polarity of electromagnet at X	Direction of motion of wire Y
A.	South	Into page
B.	South	Out of page
C.	North	Into page
D.	North	Out of page

68. How many litres of hydrogen, $H_2(g)$, measured at STP, are needed to combine exactly with 1.50 L of nitrogen, also measured at STP, to form ammonia?

A. 22.4 L $H_2(g)$
B. 20.9 L $H_2(g)$
C. 4.50 L $H_2(g)$
D. 0.50 L $H_2(g)$

69. As part of a rock analysis, a student added hydrochloric acid to a rock sample and observed a fizzing action, indicating that a gas was being released. The student collected a sample of the gas in a 0.220 L gas bulb until its pressure reached 0.757 atm at a temperature of 25.0 °C. The sample weighed 0.299 g. Point out the likely source of the gas below:

A. 34 g/mol H_2S
B. 27 g/mol HCN
C. 44 g/mol CO_2
D. 64 g/mol SO_2

70. What type(s) of intermolecular forces exist between the following pairs:

(i) HBr and H_2S
(ii) Cl_2 and CBr_4
(iii) I_2 and NO_3^-
(iv) NH_3 and C_6H_6?

	(i)	(ii)	(iii)	(iv)
A.	dipole-dipole forces, as well as dispersion forces.	dispersion force only	ion-induced dipole forces and dispersion forces.	dipole-induced dipole forces and dispersion forces.
B.	ion-dipole forces	ion-induced dipole forces only	dipole-dipole forces	dipole-induced dipole forces
C.	ion-dipole forces	dipole-induced dipole forces only	ion-induced dipole forces and dispersion forces.	dipole-induced dipole forces and dispersion forces.
D.	dipole-dipole forces, as well as dispersion forces.	dispersion force only	dipole-induced dipole forces and dispersion forces	ion-dipole forces

71. A compound X is heated in a test tube. When a glowing splinter is held at the mouth of the test tube, the splinter bursts into flames. Compound X is ...

A. $NaNO_3$
B. $NaHCO_3$
C. $Ca(OH)_2$
D. $NH_4C\ell$

72. In a transformer, the changing current in the primary coil induces a changing magnetic field in the ...

A. conductor.
B. secondary coil.
C. inductor.
D. resistor.

73. Examine the options below and choose the correct formula of the compound whose name is hexaamminechromium(III) nitrate

A. $[Cr(NH_3)_6](NO_3)_3$
B. $[Cr(NO_3)_3](NH_3)_6$
C. $[Cr(NH_2)_6]NO_3$
D. $[Cr(NH_3)_6](NO_2)_3$

74. The power in the wind depends on the wind velocity. It is proportional to:

A. the wind velocity
B. the square of the wind velocity
C. the cube of the wind velocity
D. None of the above

75. Predict the direction of the reaction, if you mix equal concentrations of reactants and products for:

(i) $H_2SO_4(aq) + NH_3(aq) \rightleftharpoons NH_4^+(aq) + HSO_4^-(aq)$
(ii) $HCO_3^-(aq) + SO_4^{2-}(aq) \rightleftharpoons HSO_4^-(aq) + CO_3^{2-}(aq)$

A. (i) Left to right and (ii) right to left
B. (i) Left to right and (ii) left to right
C. (i) Right to left and (ii) right to left
D. (i) Right to left and (ii) left to right

76. The concentration of H_3O^+ ions in a sample of lemon juice is $2.5x10^{-3}\ mol.dm^{-3}$.
Calculate the concentration of OH^- ions, and classify the solution as acidic, neutral, or basic.

A. $2.5x10^{11}\ mol.dm^{-3}$, basic
B. $2.5x10^{-11}\ mol.dm^{-3}$, acidic
C. $4.0x10^{12}\ mol.dm^{-3}$, basic
D. $4.0x10^{-12}\ mol.dm^{-3}$, acidic

77. Simon drove a distance of 90 km from 10:45 am to 11:30 am. What was his average speed in km/h?

A. 2 km/h
B. 90 km/h
C. 120 km/h
D. 130 km/h

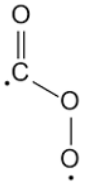
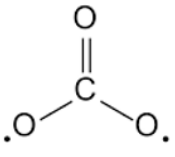
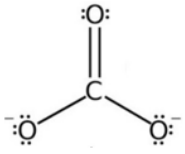
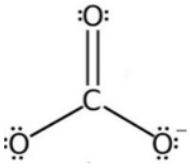
78. Lycopene is an organic compound with many conjugated double bonds and is a red pigment found in tomatoes. Why do the tomatoes appear red?

A. Lycopene absorbs visible light at 470 nm in the blue-green region.
B. Lycopene transmits light of 470 nm in blue-green region.
C. Lycopene absorbs visible light at 640 nm in the red region.
D. Lycopene is responsible for the addition of red colour at 640 nm.

79. Approximately how much time does it take for rays from the Sun to reach Earth?

A. 21 minutes
B. 12 minutes
C. 9 minutes
D. 8 minutes

80. Which of the following is the Lewis structure for the carbonate ion?

A. 
B. 
C. 
D. 

81. In comparing the sizes of Cl^-, Ar, and Ca^{2+}. Which of the following statements is FALSE?

A. Each of these atoms or ions has 18 electrons.
B. The greater positive charge in the Ca^{2+} nucleus (20 protons) has a greater pull on the electrons than do the smaller charges in Ar (18 protons) and Cl^- (17 protons).
C. Ca^{+2} is the *smallest* and Cl^- is the *largest* of these three.
D. None of the above

82. A certain element has a mass number of $(2x + 4)$ where x is the atomic number. The number of neutrons in the nucleus of the atom is

A. $x - 4$
B. $2x$
C. $x + 4$
D. x

83. Many renewable energy technologies have shown high growth rates since 2010. However, in the Greenpeace scenario which two are only given a 1% annual growth rate?

A. Wind and solar PV
B. Bioenergy and hydro
C. CSP and geothermal
D. None of the above

84. Which one of the following will be used to carry electric current in long-distance undersea electric cables?

A. High voltage alternating current (HVAC)
B. High voltage direct current (HVDC)
C. Low voltage direct current (LVDC)
D. Low voltage alternating current (LVAC)

85. Eight square tiles are attached together and arranged to form a square pattern with a hole in the center. If the tiles are heated, does the size of the hole

A. Decrease
B. Increase
C. Stay the same
D. Contract, then expand later

86. A car moves at a constant speed along a straight line as it approaches a circular turn. In which of the following part(s) of the motion is the car in equilibrium?

A. As it moves along the straight line toward the circular turn
B. As it is going around the turn
C. As it moves away from the turn along a straight line.
D. Both A and C

87. Two resistors, R_1 = 'R' and R_2 = '½ R' are connected in parallel in a circuit. An ammeter is connected in series to the circuit and reads 3 A. If the voltage across the battery is 12 V, then the current in R_1 will be:

A. 2 A
B. 3 A
C. 1 A
D. 6 A

88. The Plumber uses two methods for pumping water from a well. In one method, the pump is submerged in the water at the bottom of the well, while in the other, it is located at ground level. If the well is shallow, either technique can be used. If the well is very deep, which pumping method works?

A. The submerged pump
B. The pump located at ground level
C. Both the submerged pump and the pump located at ground level
D. None of the above

89. The gravitational acceleration of a body of mass 'm' on Earth is 'g'. The Earth's mass is 'M'. The object is moved to planet 'Z' having a mass five times that of the Earth and the same radius as the Earth. The gravitational acceleration the body experiences on planet 'Z' will be:

A. 25 g
B. 0 g
C. ⅕ g
D. 5 g

90. If you look carefully at the bubbles rising in a glass of beer, you'll see them grow in size as they move upward, often doubling in volume by the time they reach the surface. Beer bubbles contain CO_2, a gas that is dissolved in the beer because of the fermentation process. Which variable describing the gas is responsible for the growth of the rising bubbles?

A. The Kelvin temperature T
B. The absolute pressure P
C. The number of moles n
D. None of the above

91. Tarpaulin is a piece of canvas that is used to cover a cargo. Whenever the truck stops, the tarpaulin lies flat. Why does it bulge outward whenever the truck is speeding down the highway?

A. The air rushing over the outside surface of the canvas creates a higher pressure than does the stationary air inside the cargo area.
B. The air rushing over the outside surface of the canvas creates a lower pressure than does the stationary air inside the cargo area.
C. The air inside the cargo area heats up, thus increasing the pressure on the tarp and pushing it outward.
D. None of the above

92. In a free fall experiment, two identical bodies fall freely from rest from two different heights. Air resistance is negligible and the times taken to reach the ground are 1 s and 2 s respectively. Point out the ratio of the two heights:

A. 1:2
B. 1:4
C. 1:8
D. 1:16

93. Which ONE of the following chemistry fact is FALSE?

A. Wood has to be heated to 260°C before it bursts into flames.
B. Before wood burns, the water in it boils off. This produces sizzling sounds.
C. The smoke produced when wood burns contains more than 100 substances.
D. None of the above

94. The date of manufacture of food items fried in oil should be checked before buying because oils become rancid due to:

A. oxidation
B. reduction
C. hydrogenation
D. decrease in viscosity

95. Used primarily in fertilisers, which element is never found free in nature even though it makes up approximately 2.5% of the Earth's crust?

A. Mercury
B. Potassium
C. Iron
D. Magnesium

96. To protect a submerged iron pipeline from corrosion, a bar of magnesium is attached to the pipe. Which one of the following statements best explains the protective action that will take place?

A. Mg gains electrons more readily than Fe, keeping the Fe from oxidising.
B. Mg forms a self-protective coating over the Fe pipe.
C. Mg is more active than Fe and forces Fe to act as an anode.
D. Fe loses electrons less readily than Mg, making Mg the anode.

97. Deep blue colour is imparted to glass by the presence of

A. cupric oxide
B. nickel oxide
C. cobalt oxide
D. iron oxide

98. Point out the best experimental technique for measuring the bond lengths within molecules when the species are in the gas phase?

A. Electron diffraction
B. Infrared spectroscopy
C. Nuclear magnetic resonance spectroscopy
D. X-ray diffraction

99. The concentration of sodium ions in a water sample was measured as 4.57×10^{-3} mol dm^{-3}. What is this concentration expressed as parts per million?

A. 457 ppm
B. 105 ppm
C. 197 ppm
D. 952 ppm

100. Which of the following is FALSE about automobile engines?

A. Most cars today still use the same combustion system invented by Alphonse Bear de Rochas in 1862.
B. Regular, small explosions occurring in sequence in the cylinders of an automobile engine provide the energy to drive a car.
C. In complete combustion, components of gasoline and oxygen combine in the cylinders to form carbon dioxide and water.
D. None of the above

~~~XXX~~~~
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TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	$9,8\ m\cdot s^{-2}$
Universal gravitational constant	G	$6,67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
Radius of Earth	R_E	$6,38 \times 10^{6}\ m$
Mass of Earth	M_E	$5,98 \times 10^{24}\ kg$
Speed of light in a vacuum	c	$3,0 \times 10^{8}\ m\cdot s^{-1}$
Planck's constant	h	$6,63 \times 10^{-34}\ J\cdot s$
Coulomb's constant	k	$9,0 \times 10^{9}\ N\cdot m^2\cdot C^{-2}$
Charge on electron	e	$-1,6 \times 10^{-19}\ C$
Electron mass	m_e	$9,11 \times 10^{-31}\ kg$

TABLE 2: FORMULAE

MOTION

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ or $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^{\,2} = v_i^{\,2} + 2a\Delta x$ or $v_f^{\,2} = v_i^{\,2} + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ or $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$

WORK, ENERGY AND POWER

$W = F\Delta x\cos\theta$	$U = mgh$ or $E_P = mgh$
$K = \frac{1}{2}mv^2$ or $E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta K$ or $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ or $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ or $W_{nc} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{ave} = Fv_{ave}$	

FORCE

$F_{net} = ma$	$p = mv$
$f_s^{max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\frac{m_1 m_2}{d^2}$ or $F = G\frac{m_1 m_2}{r^2}$	$g = G\frac{M}{d^2}$ or $g = G\frac{M}{r^2}$

WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ or $f_L = \frac{v \pm v_L}{v \pm v_b} f_b$	$E = hf$ or $E = \frac{hc}{\lambda}$
$E = W_0 + E_{k(max)}$ or $E = W_0 + K_{max}$ where $E = hf$ and $W_0 = hf_0$ and $E_{k(max)} = \frac{1}{2}mv_{max}^2$ or $K_{max} = \frac{1}{2}mv_{max}^2$	

ELECTRIC CIRCUITS

$R = \frac{V}{I}$	emf (ε) = I(R + r) emk (ε) = I(R + r)
$R_s = R_1 + R_2 + \ldots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	$q = I\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$

ALTERNATING CURRENT

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ $V_{rms} = \frac{V_{max}}{\sqrt{2}}$	$P_{ave} = V_{rms}I_{rms}$ $P_{ave} = I_{rms}^2 R$ $P_{ave} = \frac{V_{rms}^2}{R}$

ELECTROSTATICS

$F=\frac{kQ_1Q_2}{r^2}$	$E=\frac{kQ}{r^2}$
$V=\frac{W}{q}$	$E=\frac{F}{q}$
$n=\frac{Q}{e}$ or $n=\frac{Q}{q_e}$	

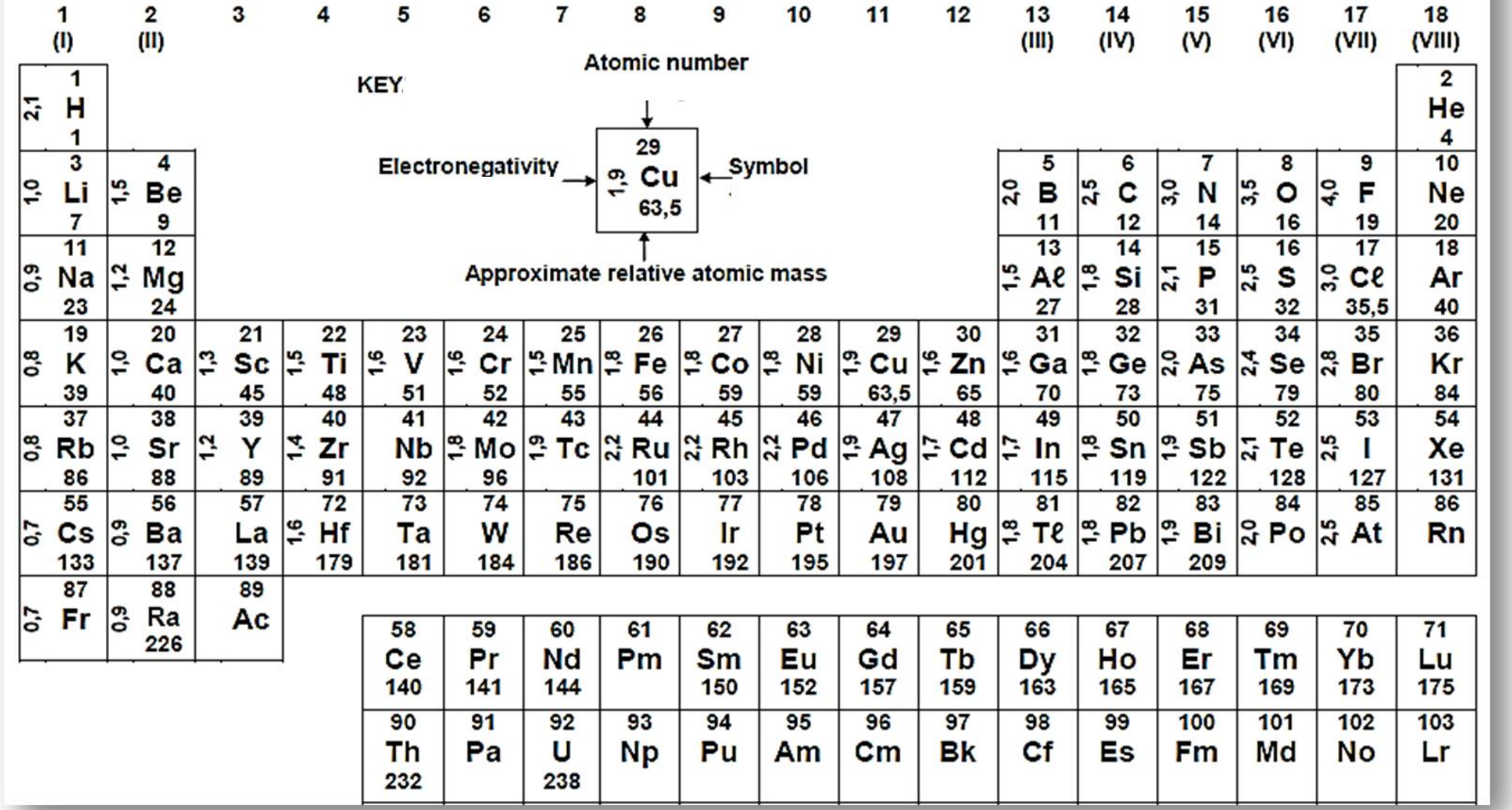
TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^θ	$1,013 \times 10^5$ Pa
Molar gas volume at STP	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature	T^θ	273 K
Charge on electron	e	$-1,6 \times 10^{-19}$ C
Avogadro's constant	N_A	$6,02 \times 10^{23}$ mol^{-1}

TABLE 2: FORMULAE

$n=\frac{m}{M}$	$n=\frac{N}{N_A}$
$c=\frac{n}{V}$ or $c=\frac{m}{MV}$	$n=\frac{V}{V_m}$
$\frac{c_a v_a}{c_b v_b}=\frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at 298 K	
$E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$ or $E^\theta_{cell} = E^\theta_{reduction} - E^\theta_{oxidation}$ or $E^\theta_{cell} = E^\theta_{oxidisingagent} - E^\theta_{reducingagent}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS



1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

							58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
							90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 4A: STANDARD REDUCTION POTENTIALS

Half-reactions	E^θ (V)
$F_2(g) + 2e^- \rightleftharpoons 2F^-$	+ 2,87
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+ 1,81
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+ 1,51
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^- \rightleftharpoons Pt$	+ 1,20
$Br_2(\ell) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^- \rightleftharpoons Hg(\ell)$	+ 0,85
$Ag^+ + e^- \rightleftharpoons Ag$	+ 0,80
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+ 0,77
$O_2(g) + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+ 0,68
$I_2 + 2e^- \rightleftharpoons 2I^-$	+ 0,54
$Cu^+ + e^- \rightleftharpoons Cu$	+ 0,52
$SO_2 + 4H^+ + 4e^- \rightleftharpoons S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^- \rightleftharpoons 4OH^-$	+ 0,40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+ 0,16
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+ 0,15
$S + 2H^+ + 2e^- \rightleftharpoons H_2S(g)$	+ 0,14
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	0,00
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	– 0,06
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	– 0,13
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	– 0,14
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	– 0,27
$Co^{2+} + 2e^- \rightleftharpoons Co$	– 0,28
$Cd^{2+} + 2e^- \rightleftharpoons Cd$	– 0,40
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	– 0,41
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	– 0,44
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	– 0,74
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	– 0,76
$2H_2O + 2e^- \rightleftharpoons H_2(g) + 2OH^-$	– 0,83
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	– 0,91
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	– 1,18
$Al^{3+} + 3e^- \rightleftharpoons Al$	– 1,66
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	– 2,36
$Na^+ + e^- \rightleftharpoons Na$	– 2,71
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	– 2,87
$Sr^{2+} + 2e^- \rightleftharpoons Sr$	– 2,89
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	– 2,90
$Cs^+ + e^- \rightleftharpoons Cs$	- 2,92
$K^+ + e^- \rightleftharpoons K$	– 2,93
$Li^+ + e^- \rightleftharpoons Li$	– 3,05

Increasing oxidising ability ↑

Increasing reducing ability ↓

TABLE 4B: STANDARD REDUCTION POTENTIALS

Half-reactions	E^θ (V)
$Li^+ + e^- \rightleftharpoons Li$	– 3,05
$K^+ + e^- \rightleftharpoons K$	– 2,93
$Cs^+ + e^- \rightleftharpoons Cs$	– 2,92
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	– 2,90
$Sr^{2+} + 2e^- \rightleftharpoons Sr$	– 2,89
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	– 2,87
$Na^+ + e^- \rightleftharpoons Na$	– 2,71
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	– 2,36
$Al^{3+} + 3e^- \rightleftharpoons Al$	– 1,66
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	– 1,18
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	– 0,91
$2H_2O + 2e^- \rightleftharpoons H_2(g) + 2OH^-$	– 0,83
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	– 0,76
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	– 0,74
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	– 0,44
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	– 0,41
$Cd^{2+} + 2e^- \rightleftharpoons Cd$	– 0,40
$Co^{2+} + 2e^- \rightleftharpoons Co$	– 0,28
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	– 0,27
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	– 0,14
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	– 0,13
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	– 0,06
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	0,00
$S + 2H^+ + 2e^- \rightleftharpoons H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+ 0,15
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+ 0,34
$2H_2O + O_2 + 4e^- \rightleftharpoons 4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^- \rightleftharpoons S + 2H_2O$	+ 0,45
$Cu^+ + e^- \rightleftharpoons Cu$	+ 0,52
$I_2 + 2e^- \rightleftharpoons 2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+ 0,68
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+ 0,77
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^- \rightleftharpoons Ag$	+ 0,80
$Hg^{2+} + 2e^- \rightleftharpoons Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$Pt^{2+} + 2e^- \rightleftharpoons Pt$	+ 1,20
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+ 1,33
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1,77
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+ 1,81
$F_2(g) + 2e^- \rightleftharpoons 2F^-$	+ 2,87

Increasing oxidising ability ↓

Increasing reducing ability ↑