



Kinematics

1. A girl rides a bike and travels 12 km in a quarter an hour. Calculate the speed in km.h^{-1} and m.s^{-1}
Sol: 48 km.h^{-1} ; 13,3 m.s^{-1}

2. Ana needs 45 minutes to arrive to her high school, which is 3 km far away from her home. She stays at school for five hours and she comes back to home walking for an hour. Plot the graph s/t y v/t and calculate her speed in each phase
Sol: 4 km.h^{-1} ; 3 km.h^{-1}

3. A car travels at 72 km.h^{-1} through a road. Calculate the time needed to cover a distance of 100 km. Express the speed in m.s^{-1} and the distance travelled in 10 minutes
Sol: 83'20"; 20 m/s; 12 km

4. Speed limits in UK are 30, 50 and 70 miles per hour. Convert these limits in km.h^{-1} and m.s^{-1} . A mile is equal to 1609 m
Sol: 48, 90 & 112 km.h^{-1}

5. A car starts from rest and accelerates uniformly to 120 km.h^{-1} for 8 seconds. Determine the acceleration and the distance covered
Sol: 4,17 m/s^2 ; 133 m

6. A tile falls down from the top of a building 30 m above the ground. Calculate the time required to arrive to the ground and its speed
Sol: 2,47 s; 24,3 m/s

7. A driver who is moving at 20 m.s^{-1} notices a huge rock on the road, and he needs 10 s to stop his car. Calculate the acceleration and the distance travelled
Sol: - 2 m/s^2 ; 100 m

8. A bike starts accelerating at a rate of 1.5 m.s^{-2} , covering 40 m. Then it continues moving at the same speed for 10 s. Finally, it slows down and it stops covering 15 m. Determine the final speed of the first stage, the total time taken and the distance. Plot the graph v/t
Sol: 10,95 m/s, 20 s, 164,5 m

9. A vehicle starts from rest accelerating uniformly at a rate of 3 m.s^{-2} for 5 s. Then it continues moving uniformly for 10 s. Finally it slows down until rest for 3 s. Determine the speed of each stage and the total distance travelled
Sol: 15 m/s; 210 m

10. Pilar is driving at 90 km.h^{-1} and she notices a traffic jam at a distance of 80 m. Calculate the acceleration required to avoid crashing against the cars. What is the time taken along the motion?
Sol: 3.9 m.s^{-2} ; 6,4 s

11. A 100 m-runner starts accelerating uniformly at 4 m.s^{-2} and he reaches his limit speed after 3 seconds. Then he keeps running at the same speed until the end of the race. Calculate the limit speed and the time required to finish the race
Sol: 12 m/s; 9,83 s

12. Maria throws vertically upwards a stone at 25 m.s^{-1} . Calculate the maximal height reached by the particle and the speed when it is 20 m above the ground
Sol: 31,9 m; 15,2 m.s^{-1}

13. A brick falls down from the top of a building which is 250 m high. First it accelerates uniformly, but it reaches a limit speed after 5 s. Then it keeps its speed until the ground. Determine the total time required for the stone to arrive to the ground. Plot the graph v/t and s/t

14. A centrifuge spins at a rate of 800 rpm. Determine frequency and period of the motion. Calculate the angular speed, and velocity and centripetal acceleration of a point placed at 30 cm from the centre
Sol: 0,075 s; 25,1 m/s; 2105 m/s^2

15. A car engine spins at a rate of 2400 rpm. Find the period and frequency of the motion. Determine the angular speed and the velocity and centripetal acceleration of a point placed 10 cm from the centre
Sol: 0,025 s; 251 rad/s; 25 m.s^{-1} ; 6250 m/s^2



Kinematics

16. Carmen drops a stone into a narrow well. The stone falls down and she hears the echo 3 seconds later. Determine the depth of the well if the speed of the sound is 340 m.s^{-1}

Sol: 41 m

17. An aeroplane starts from rest accelerating at 3.2 ms^{-2} . Calculate the speed when it takes off if it has covered a distance of 1700 m. What is the time taken for the plane to take off?

Sol: 104 m.s^{-1} ; 32,6 s

18. Gravity on the Moon is $1,67 \text{ m.s}^{-2}$. Calculate the time taken for a feather to fall down a height of 1.5 m, as it was carried out by Apollo15 crew. Compare this time with the time taken on Earth

Sol: 1,34 s; 0,55 s

19. A proton at rest needs 20 minutes to reach the speed of light ($c = 3.10^8 \text{ m.s}^{-1}$) to access in the tunnel of LHC, in Geneva. Calculate the average acceleration of a proton, and the total distance travelled

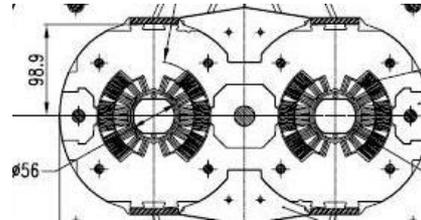
Sol: $3,64.18^8 \text{ km}$

20. Protons in LHC complete 11425 revolutions per second. Calculate their angular velocity and period. Determine their centripetal acceleration if the tunnel is 26.5 km long and compare it with gravity

Sol: $90 \mu\text{s}$; 68700 rad.s^{-1}

21. A proton at LHC falls down due to gravity. The diameter of the pipe is 56 mm, as it is shown in the cross section. Calculate the time taken for the proton to go out of the pipe and the number of cycles covered

Sol: 76 ms; 850 revolutions



22. A wheel turns at a rate of 120 rpm. Find the period and frequency of the motion. Determine the angular speed and the velocity and centripetal acceleration of a point placed 10 cm from the centre

Sol: 0,5 s; 2 Hz; $12,6 \text{ rad.s}^{-1}$; $1,26 \text{ m.s}^{-1}$; $15,8 \text{ m.s}^{-2}$

23. Alfredo throws his mother's watch vertically upwards from her flat's window, placed at 25 m height and measures 5 seconds until the watch reaches to the ground. Determine the initial velocity of the watch and its speed when it is smashed on the street. What is the maximal height reached by the watch along the experiment?

Sol: $29,5 \text{ m.s}^{-1}$; $- 19,5 \text{ m.s}^{-1}$; 44,4 m

24. A computer's hard disk drive turns at 720 rpm and its radius is 9 cm long. Calculate its period and frequency; its angular velocity; and its velocity and acceleration at the edge of the disk

Sol: 0,083 s; 12 Hz; $75,4 \text{ rad.s}^{-1}$; $6,8 \text{ m.s}^{-1}$; 511 m.s^{-2}

25. A carousel turns at 12 rpm. Determine the period of the motion. Calculate the velocity and acceleration of a passenger who is placed at 3 m far away from the centre

26. An engineer is designing the runway for an airport. Of the planes that will use the airport, the lowest acceleration rate is likely to be 3 m/s^2 . The take-off speed for this plane will be 65 m/s. Assuming this minimum acceleration, what is the minimum allowed length for the runway?

Sol: 704 m © physicsclassroom.com

27. A tractor has two kinds of wheels, whose diameters are 60 and 130 cm. Assuming that the tractor is moving at 30 km/h, calculate period and frequency for each wheel and the accelerations at a point placed at the edge of the wheel

Sol: 0,226 s; 0,49 s; 4,42 Hz; 2,0 Hz; 231 and 107 m.s^{-2}

28. A nickel falls down from the top of a skyscraper at 350 m above the ground. Calculate the time for the penny to arrive to the street. Then it is embed into a lump of moist clay at a depth of 10 cm. Calculate the acceleration and the time taken to stop

Sol: 8,45 s; 414 m.s^{-2} ; 22 ms



Dynamics

1. A spring stretches 5 cm when a 20 N force is applied upon it. Determine the constant of the spring of the spring and the extension produced by 37 N **Sol: 400 N.m⁻¹ ; 9,25 cm**

2. When a 100 g body is hanged at the end of a spring, we observe an extension of 4 cm. Determine the constant of the spring and the force needed to stretch 7.5 cm
Sol: 24,5 N.m⁻¹; 1,84 N

3. A spring is stretched from 10 to 16 cm when a force of 3 N is applied to it. Determine the constant of the spring and the force needed to get a length of 30 cm
Sol: 50 N.m⁻¹; 10 N

4. A car, which has 800 kg, starts from rest. Its engine applies a force equal to 1500 N to the wheels and the coefficient of friction is 0.1. Draw the free body diagram of the car. Calculate the acceleration of the car and the distance travelled and its velocity after 10 s
Sol: 0,895 m.s⁻² ; 44,75 m; 8,95 m.s⁻¹

5. Ines wants to move a wardrobe, whose mass is 90 kg, applying a horizontal force equal to 500 N. If coefficient of friction between wood and floor is 0,3, draw a diagram of forces applied to it and calculate the acceleration of the body. What is the time taken to move it along 2 m and its final velocity? **Sol: 2,62 m.s⁻²; 1,24 s; 3,2 m.s⁻¹**

6. An astronaut weighs 750 N on the Earth. What is his weight on the Moon, if a body falls down on the Moon at 1,6 m/s⁻²? **Sol: 122 N**

7. A car which has 1200 kg slows down from 130 km.h⁻¹ to 80 km.h⁻¹ along 150 m. Calculate its acceleration, the force of friction applied upon it and the coefficient of friction between its tyres and the road **Sol: 2,7 m.s⁻² ; 3330 N; 0.27**

8. Compare the force needed for a 3 kg-body to get an acceleration equal to 0,5 m/s⁻² :
a) if we want to move it on a non-friction horizontal surface
b) if we want to move it on a horizontal surface which applies a force of friction which is 40 N
c) if we want to pull it vertically upwards **Sol: 1,5 N; 41,5 N; 30,9 N**

9. A body, which has 5 kg, is placed on a horizontal surface. The coefficient of friction is 0.1. Calculate the minimal force needed to move it. What happens when a 3 N force is applied upon the body? What is the acceleration of the motion if a 15 N force is applied to it?
Sol: 4,9 N; - ; 2,02 m.s⁻²

10. David stands up on a scale placed in his elevator. The measurement of the scale is 70 kg. Find the mass measured a) if the elevator starts form rest vertically upwards at 2 m.s⁻²
b) rise up uniformly at 3 m.s⁻¹ c) slows down at 1 m.s⁻² **Sol: 84,3 kg; 70 kg; 62,8 kg**

11. A box, which has 2 kg, is hanged at the end of a wire. Determine the force which is needed to move the object a) vertical upwards at 1 m.s⁻¹
b) vertically downwards at 2 m.s⁻¹ c) vertically upwards with an acceleration 3 m.s⁻²
d) vertically downwards with an acceleration 1 m.s⁻² **Sol: 19,6 N; 19,6 N; 25,6 N; 17,6 N**

12. An object of 250 g turns at 30 rpm. Determine the centripetal force considering its radius is equal to 50 cm **Sol: 1,23 N**

13. The 30 cm-wheels of a bike turn at 480 rpm. Determine its period and frequency. Find the acceleration of a point at the edge of the wheels and the force applied upon the tyre, which has 100 g **Sol: 0,125 s; 8 Hz; 758 m.s⁻² ; 75,8 N**

14. A carousel turns at 15 rpm. Find its period and frequency. Determine the acceleration and force applied upon a 35 kg-child who is placed at 3 m from the centre
Sol: 4 s; 7,4 m.s⁻² ; 259 N



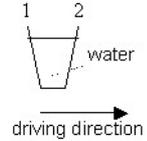


Dynamics

15. A bus is moving along a straight stretch of a road. The bus driver, named Ray, has a cup of water resting on the dashboard. Suddenly Ray has to slam on the brakes. What is most likely to happen to the water in the cup?

- A. The water will stay horizontal. B. The water will spill over side 1
C. The water will spill over side 2

D. The water will spill but you cannot tell if it will spill at side 1 or side 2. **(PISA tests)**



16. A car is turning at 90 km/h along a curve whose radius is 100 m. Determine the coefficient of friction required for the car to take the curve, considering that the force of friction is responsible of the motion and the mass of the car is 800 kg **Sol: 0,64**

17. A body of 3 kg is placed on a flat surface, which has a coefficient of friction equal to 0,15. Calculate the force required to move the object considering
a) the force is parallel to the surface b) the force makes an angle of 45° to the baseline

Sol: 4,4 N;

18. A body is placed on a ramp, which makes an angle of 45° to the ground. The coefficient of friction between the surface and the object is 0,2. Calculate the acceleration of the object. What is the force required to pull the object upwards? **Sol:**

19. Paula and Guillermo are holding a rod, which is 3 m long. Calculate the force applied by them to transport a 100 kg load when it is placed at 1 metre away from Guillermo. Where must they place the load so that Paula holds a fourth of the load?

Sol: 327 N / 653 N; 0,75 m

20. Ana and Javier are sitting on a seesaw, which is 3 metres long, and stands on its centre. Their masses are 35 and 65 kg respectively. Determine the point where Javier must sit to balance the seesaw, considering Ana sit at the end **Sol: 0,81 m**



Gravitation

1. The mass of the Moon is $7,36 \cdot 10^{22}$ kg and its radius, $1,74 \cdot 10^6$ m. Determine gravity on the Moon. Compare the distance covered by a stone in a second on the Earth and on the Moon. $G = 6,67 \cdot 10^{-11}$ N.kg².m⁻² **Sol: 4,9 and 0,81 m**

2. Saturn has a mass 95,2 times greater than the Earth's and its radius is 9.47 times greater. Find its gravity **Sol: 1.06.g: 10.4 m.s⁻²**

3. The first satellite, Sputnik I, was launched in 1957. Its period was 96 minutes and it revolved at an average height equal to 570 km. Calculate its velocity, considering that the radius of the Earth is 6370 km. Imagine that it could be stopped by a meteorite and started to fall down to the Earth. Calculate its velocity, considering that friction is negligible
Sol: 7.6 km.s⁻¹; 3340 m.s⁻¹

4. Determine the point between the Earth and the Moon which has no gravity, which is called Lagrangian point. Their masses are $5,98 \cdot 10^{24}$ and $7,36 \cdot 10^{22}$ kg respectively and the distance is $3,84 \cdot 10^8$ m **Sol: 3,45.10⁸ m**

5. Sunlight rays take 8.31 minutes to arrive to the Earth. Considering that speed of light is $3 \cdot 10^8$ m.s⁻¹ determine the angular velocity of the Earth, its linear velocity and acceleration Find the mass of the Sun **Sol: 2.10⁻⁷ rad.s⁻¹; 30 km.s⁻¹; 0.006 m.s⁻²; 2.10³⁰ kg**

6. Calculate the mass and density of Mercury, considering that its radius is 2440 km and gravity on its surface, $3,7$ m.s⁻². Determine the high jump record in Mercury, considering that the actual record on Earth is 2,45 m **Sol: 3,3.10²³ kg; 5400 kg.m⁻³**

7. Determine gravity on Jupiter, considering that its mass is $1,9 \cdot 10^{27}$ kg and its radius is 69900 km. What is its density? **Sol: 26 m.s⁻²; 1300 kg.m⁻³**

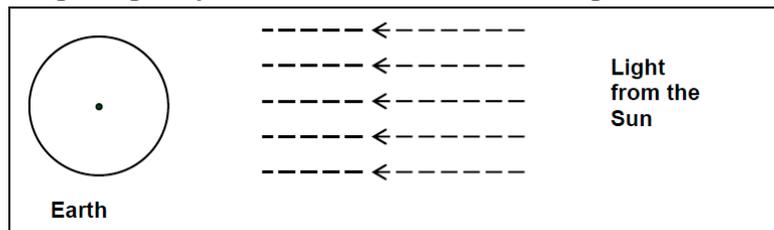
Today, as the Northern Hemisphere celebrates its longest day, Australians will experience their shortest. In Melbourne, Australia, the Sun will rise at 7:36 am and set at 5:08 pm, giving nine hours and 32 minutes of daylight.

Compare today to the year's longest day in the Southern Hemisphere, expected on 22 December, when the Sun will rise at 5:55 am and set at 8:42 pm, giving 14 hours and 47 minutes of daylight.

The President of the Astronomical Society, Mr Perry Vlahos, said the existence of changing seasons in the Northern and Southern Hemispheres was linked to the Earth's 23-degree tilt

8. Which statement explains why daylight and darkness occur on Earth? A The Earth rotates on its axis. B The Sun rotates on its axis. C The Earth's axis is tilted. D The Earth revolves around the Sun. **(PISA tests)**

9. In the Figure light rays from the Sun are shown shining on the Earth.



Suppose it is the shortest day in Melbourne. Show the Earth's axis, the Northern Hemisphere, the Southern Hemisphere and the Equator on the Figure. Label all parts of your answer. **(PISA tests)**



Gravitation

10. On 8 June 2004, the planet Venus could be seen passing in front of the Sun when viewed from many places on Earth. This is called a "transit" of Venus and happens when its orbit takes Venus between the Sun and Earth. The previous transit of Venus occurred in 1882 and another is predicted to occur in 2012.

Below is a picture of the transit of Venus in 2004. A telescope was pointed at the Sun and the image projected onto a white card



Why was the transit observed by projecting the image onto a white card, rather than by looking directly through the telescope?

- A. The Sun's light was too bright for Venus to show up.
 - B. The Sun is big enough to see without magnification.
 - C. Viewing the Sun through a telescope may damage your eyes.
 - D. The image needed to be made smaller by projecting it onto a card
- (PISA tests)**

11. When viewed from Earth, which one of the following planets can be seen in transit across the face of the Sun at certain times?

- A Mercury B Mars C Jupiter D Saturn **(PISA tests)**

12.



Pressure

1. What is the pressure applied by a skier which has 80 kg on the snow if the area of his boot is 250 cm²? Compare this pressure with the pressure applied by the area of his skis, which is 3200 cm²? **Sol: 15680 Pa; 2450 Pa**

2. Compare the pressure exerted by a 1500 kg-car, which is acting on its 4 wheels, with the pressure applied by a motorcycle, which has 300 kg. The area of each wheel is 50 and 20 cm², respectively **Sol: 735 kPa; 735 kPa**

3. What is the pressure acting on a submarine submerged at a depth of 500 m?. What is the force required to open a hatchway whose radius is 20 cm?
Density of sea water: 1030 kg.m⁻³ **Sol: 5,05 MPa; 634 kN**

4. In 1648 Pascal carried out an experiment to check that air pressure explained the height of a column of mercury in Torricelli's barometer. He climbed up the Puy de Dôme and observed a pressure whose height was 84 mm Hg shorter than the one at the bottom of the mountain. Calculate its height, considering that the average density of air is 1,2 g/l
Sol: 950 m

5. What is the pressure that a sunk ship has to stand at a depth of 100 m? What is the force required to open a door which is 2 m high and 80 cm wide?
Density of sea water is 1030 kg.m⁻³ **Sol: 1009 kPa; 1615 kN**

6. An open U-shaped tube contains water ($\rho = 1000 \text{ kg/m}^3$). We fill one of the ends with an immiscible liquid whose density is 900 kg/m³. When the system is at equilibrium the column of this liquid is 8.0 cm high. What is the difference of height between both columns of fluid?
Sol: 8 mm

7. A body weighs 150 N, but its weight immersed in water is 100 N and immersed in another liquid, 111. Determine the density of the body and density of the fluid. Density of water: 1000 kg.m⁻³ **Sol: 3000 kg.m⁻³; 780 kg.m⁻³**

8. A submarine is submerged at depth of 20 m. Determine the force required to open its hatchway whose diameter is 1 m. $\rho_{\text{water}} = 1025 \text{ kg.m}^{-3}$ **Sol: 158 kN**

9. A wood block has 800 g and its sides are 12, 9 and 8 cm, respectively. Does it float in water, whose density 1000 kg.m⁻³? **Sol: yes; 800 cm³**

10.- An ice cube whose side is 5 cm has a mass equal to 110 g. Does it float in water?. What is the immersed volume? Density of water 1000 kg.m⁻³ **Sol: si; 110 cm³**

11.- An ice cylinder has a height of 20 cm and its radius is 5 cm. Determine the height which is above the sea level when it floats. Densities of sea water and ice are, respectively, 1030 and 900 kg.m⁻³ **Sol: 2,5; 17,5 cm**

12. What is the force required to keep a wood board completely immersed in water? Density of wood is 750 kg.m⁻³ and its dimensions 50x40x10 cm. $\rho_{\text{agua}}=1000 \text{ kg.m}^{-3}$ **Sol: 49 N**

13. A cubic block of wood, which has a side equal to 10 cm floats in water, and it has 2 cm out of water. Determine the mass we have to place on the cube to immerse it completely in the fluid. **Sol: 200 g**

14. What is the force applied to the disk brake, which has an area equal to 100 cm², when we apply a 5 N force to the pedal which affects to an area equals to 0,5 cm²? **Sol: 1000 N**

15. What is the force exerted by a hydraulic Jack which has an area equals to 500 cm², when we apply a 15 N to an area equals to 10 cm²? **Sol: 750 N**





Pressure

16. Charles Darwin travelled around the Earth for 5 years on board of "Beagle". He stopped in Valparaiso and crossed the Andes range to collect stones samples. Near Portillo he tried to boil potatoes for dinner

Hence the potatoes, after remaining for some hours in the boiling water, were nearly as hard as ever. The pot was left on the fire all night, and next morning it was boiled again, but yet the potatoes were not cooked. I found out this, by overhearing my two companions discussing the cause, they had come to the simple conclusion, "that the cursed pot [which was a new one] did not choose to boil potatoes." The Voyage of the Beagle, chapter 15, 1839 © <http://infidels.org>

Explain why the potatoes were "as hard as ever" after an overnight boiling. Suggest an alternative method for boiling potatoes on the top of a mountain

17. Trees have to pump water from the edge of their roots to the leaves. Determine the pressure, which has to be exerted to lift the water from the ground to a height equals to 25 m and the force applied on a drop of water whose radius is 1 mm

Sol. 245 kPa; 0,77 N

18. Which one is heavier, a tone of straws or a tone of iron? Compare their buoyant force in air. Densities ($\text{kg}\cdot\text{m}^{-3}$): air: 1.3; iron: 7900; straw: 150

19.





Energy, work & heat

1. A pump lifts water from the ground to a 50 m^3 -tank, which is placed 30 m higher. What is the work required to fill the tank? What is the power of the engine, considering it takes half an hour to fill the tank? **Sol: 14700 kJ; 8166 W**

2. An elevator rises up from the ground to the top of a building which is 15 m high. Find the work done by the weight, considering that its mass is 1500 kg and it lifts four people who have 60 kg. What is the power of the engine if it takes 15 s to cover the distance?
Sol: 256 kJ; 17 kW

3. Find the power of a car engine, considering it takes 10 seconds to accelerate from rest to 110 km/h. The mass of the car is 1500 kg. Convert the power to HP **Sol: 70 kW; 93 HP**

4. A roller coaster car starts from rest at a height of 20 m and slides down along an incline ramp. Determine its speed at a height of 15 m. What is its velocity when it arrives at the ground?. Calculate the height at which its velocity is 15 m/s **Sol: 9,9 m/s; 19,8 m/s; 8,5 m**

5. A ball spins along the slope of a hill which has no friction. Consider it starts from rest at 50 metres high. What is the velocity at 20 metres high?. What is its velocity when it arrives at the ground? What is the height where its speed is 20 m/s? **Sol: 24 m/s; 31,3 m/s; 29,6 m**

6. An iron ball of 50 g is thrown at 90 km/h from the top of a building whose height is 100 m. Determine its velocity when its height is 40 m. Calculate the height at which it falls down at 50 m/s. Consider that it hits the ground and 90 % of its energy is converted into heat. How much does its temperature increase?. Specific heat capacity of iron is 440 J/kg.K
Sol: 42,4 m/s; 4,4 m; 2,6° C

7. A 600 grams brick at 500°C is immersed in a container which has 100 liters of water at 15°C . Determine the temperature of the system when it achieved its thermal equilibrium. Specific heat capacities of brick and water are 840 y 4180 J/kg.K respectively **Sol: 15,6° C**

8. Determine the quantity of heat required to warm a room whose sides are 4 and 3 m long and its height is 2,5 m from 15° to 22°C . Consider that density of air is $1,2 \text{ kg/m}^3$ and its specific heat capacity is $1012 \text{ J.kg}^{-1}.\text{K}^{-1}$. What is the time taken for a 2500 W heating system to warm the room? **Sol: 255 kJ; 1min 42 s**

9. An 1 kg-iron rod at 800°C is cooled in a bath filled with 50 liters of water at 15°C . Determine the temperature at thermal equilibrium, considering that specific heat of iron and water are 440 y 4180 J/kg.K respectively **Sol: 16,6° C**

10. A 2 kW-electric kettle is used to boil water at 15°C . What is the time taken for the kettle to boil one liter of water?. What is the time required to vaporize all the water?. Specific heat capacity: $4180 \text{ J.kg}^{-1}.\text{K}^{-1}$. Latent heat of vaporization: 2260 kJ.kg^{-1} **Sol: 2 min 57 s; 19 min**

11. What is the energy released if a 50 g drop of mercury falls down from a table which is 80 cm high to the ground?. Consider that all the heat is absorbed by the drop. What is the increase of temperature of the mercury drop?. Specific heat capacity: $139,5 \text{ J/kg.K}$
Sol: 0,392 J; 0,06° C

12. A brake system of a car slows down its motion by means of friction forces upon the brake disc. Determine the change of temperature of the brake disc when a 1200 kg car at 120 km/h stops. Consider that the brake system absorbs 15 % of the heat produced and its mass is 10 kg and its specific heat capacity is $800 \text{ J.kg}^{-1}.\text{K}^{-1}$ **Sol: 12,5° C**

13. What is the quantity of heat released when a 100 g ball of lead falls down from a balcony which is at 40 m above the ground?. Consider that 90 % of the heat is absorbed by the ball. Determine the change of temperature. Specific heat capacity 129 J/kg.K
Sol: 39.2 J; 2,7° C





Energy, work & heat

14. Determine the temperature at thermal equilibrium after adding two ice rocks which have 25 cm^3 at -10° C to a 200 cm^3 -glass filled with water at a 35° C . Density of ice: 900 kg.m^{-3} ; Specific latent heat: $4180 \text{ J.kg}^{-1}.\text{K}^{-1}$; Latent heat fusion: 334 kJ.kg^{-1} **Sol: $12,1^\circ \text{ C}$**

15. We mix 2 kg of water at 60° C and 1 kg at 0° C . Find the temperature at thermal equilibrium. Determine the temperature at equilibrium considering we mix the same amount of water with 1 kg of ice at 0° C . **Sol: 40° C , $13,3^\circ \text{ C}$**

16.- Peter is working on repairs to an old house. He has left a bottle of water, some metal nails and a piece of timber inside the boot of his car. After the car has been out in the sun for three hours, the temperature of the car reaches 40° C . What happens to the object in the car?. Do they have the same temperature?. Do you think after some time, water will begin to boil? **PISA 2012**

17. A ball falls down from a height of 2 metres, bounces at the ground and arrives to a point placed at 1,25 m. Determine the speed when it arrives to the ground and the speed after it bounces. What is the force applied by the ground, considering the bounce takes 1cs?. Determine the energy lost after the bounce and the change of temperature, considering 75 % of this energy is converted into heat.

Mass of the ball: 250 g; Specific heat capacity plastic 100 J/kg.K

18. For drinks during the day, Peter has a cup of hot coffee at a temperature about 90° C and a cup of mineral water of about 5° C . The cups are of identical size and type and the volume of each drink is the same. Peter leaves the cups sitting in a room where the temperature is about 20° C . What are the temperature of the coffee and the mineral water likely to be after 10 minutes?

A: 70 and 10° C

B. 90 and 5° C

C: 70 and 25° C

D. 20 and 20° C





Waves & light

1. A source emits monochromatic light which has a wavelength in vacuum equals to $6 \cdot 10^{-7}$ m (red coloured). Consider that light travels through water, which has an index of refraction equals to 1.34. Determine its frequency, speed and wavelength in water

Sol: $5 \cdot 10^{14}$ Hz; $2,24 \cdot 10^8$ m/s; 447 nm

2. A monochromatic ray of light passes from a medium which has an index of refraction equals to 1.58 to a different one whose index equals to 1.23. The ray of light makes an angle of 15° to the normal the boundary between these two media. Determine the angle of refraction and the critical angle for these two media

Sol: $19^\circ 25'$; 51°

3. A beam of light consists of two different rays: a blue one, which has a wavelength equals to 450 nm and a red one, whose wavelength equals to 650 nm. Determine the frequency of each colour, considering that speed of light is $3 \cdot 10^8$ m.s⁻¹. Consider that the beam hits into a flat surface and its angle of incidence is 30° , determine the angle which makes the reflected blue and red rays. Determine the angle which makes the refracted blue ray to the red one. Index of refraction of glass for the blue and red rays are, respectively, 1,55 and 1,40. **Sol: $6,7 \cdot 10^{14}$ and $4,61 \cdot 10^{14}$ Hz; 0° ; $2^\circ 6'$**

4. A ray of light travels through the air and hits on a surface of water, making an angle of 30° . What is the angle which makes the reflected ray to the refracted one?. Consider that the ray travels from the water to the air, what is the critical angle at which total reflection occurs?. Index of refraction of water is 4/3. **Sol: 128° ; $48^\circ 35'$**

5. An optic prism whose index of refraction is 1,5 is immersed in water. Its section is a isosceles right triangle. A ray of light hits perpendicularly on of the cathetus of the triangle. Explain either total reflection occurs or not. What is the emerged ray direction?

6. A scuba diver switches on a torch under the water, whose index of refraction is 1,33. The ray of light travels upwards and makes 40° to the normal. What is the refraction angle?. What is the angle of incidence at which the light cannot emerge from water?. **Sol: $58^\circ 45'$; $48^\circ 45'$**

7.- A red ray of light which travels through the air has a wavelength equals to 650 nm. When it hits the boundary between two media, it becomes 500 nm. Determine the frequency of red light and the index of refraction of the second medium. Consider that the ray of light makes an angle of 0° to the perpendicular, what is the angle of refraction of the second medium?. Consider that the ray of light reverse its direction and travels from the second medium to the air, what is the critical angle? **Sol: 1,3; $4,6 \cdot 10^{14}$ Hz; $22^\circ 37'$**

8. A ray of light whose wavelength in vacuum is 650 nm hits from air to the end of an optical fiber making an angle θ to the axis of the fiber. The fiber has an index of refraction equals to 1,46 and its sheathing 1,44. What is the wavelength of light inside the fiber?. What is the maximal angle at which total reflection occurs? **Sol: 439 nm; 20°**

9. Consider a monochromatic ray of light, whose wavelength in vacuum is 600 nm. This ray hits from air to the flat surface of a fish tank, making an angle of 30° . Determine the angle of refraction of glass, considering that its index of refraction is 1,5 and the direction of propagation through water. Determine the wavelength of light in water, considering that the index of refraction of water is 1,33 **Sol: $19^\circ 28'$; 22° ; 451 nm**





Nomenclature of Inorganic Chemistry

	Formula	Stoichiometric compositional	Traditional / oxidation number
1	SbH ₃		
2	CdO		
3	AsF ₅		
4	SrO ₂		
5	B ₂ H ₆		
6	Na ₂ SO ₃		
7	H ₂ Se		
8	PbCl ₂		
9	Cu ₂ O		
10	KMnO ₄		
11	MoBr ₂		
12	Fe(OH) ₃		
13	(NH ₄) ₂ S ₂ O ₇		
14	Ag ₂ S		
15	Zn(ClO ₃) ₂		
16	LiClO		
17	H ₂ SiO ₃		
18	Ca(OH) ₂		
19	WF ₆		
20	Hg(NO ₂) ₂		
21			Manganese (II) chloride
22			Rubidium phosphate
23		Platinum diiodide	
24			Gold (III) oxide
25			Nickel (II) hydride
26			Strontium nitrate
27		Boron trifluoride	
28		Lead dihydroxide	
29			Iron (II) sulphate
30		Potassium tetraoxidochlorate	
31		Cobalt trichloride	
32			Antimony (V) oxide
33			Aluminium hydroxide
34			Hydrochloric acid
35		Silicon tetrahydride	
36			Bromous acid
37			Sodium carbonate
38			Ammonium chromate
39			Mercury (I) sulphide
40		Paladium dioxide	





Nomenclature of Inorganic Chemistry (II)

	Formula	Stoichiometric name	Traditional / oxidation number
1	BaCl ₂	---	
2	H ₂ SO ₂		(T)
3	CO		---
4	CH ₄	---	
5	Pb(NO ₃) ₂	---	(T)
6	K ₂ S	---	
7	SrO ₂	---	
8	HIO	---	(T)
9	CoH ₃	---	
10	MgCO ₃		(T)
11	H ₂ SeO ₄		(T)
12	BeF ₂	---	
13	H ₂ S	---	(T)
14	Cd(IO ₄) ₂		
15	PtO ₂	---	
16	Sn(OH) ₄	---	
17	H ₂ SiO ₃		(T)
18	Cs ₂ SO ₃		(T)
19	Al(BrO ₃) ₃		(T)
20	HNO ₂		(T)
21	Sb ₂ O ₃		---
22	CuOH	---	
23	AsCl ₅		---
24	H ₂ CrO ₄		(T)
25	KMnO ₄		(T)
26		Dibromine heptaoxide	
27			Sodium perchlorate
28		---	Bismuth (III) hydroxide
29		---	Gold (I) hydride
30		tetrahydrogen (tetraoxidosilicate)	
31			Titanium (IV) oxide
32		Phosphorus trichloride	
33		Hydrogen(dioxidoiodate)	
34		Lead tetrakis(trioxidoiodate)	
35		Phosphane	
36			Magnesium hydroxide
37			Aluminium iodide
38			Hydrochloric acid
39		Dimercury dicloride	
40			Nitric acid
41			Nickel (II) sulfate
42			Iron (III) carbonate
43			Barium oxide
44			Platinum (IV) sulfide
45			Hydroselenic acid
46			Silver phosphate
47			Lithium borate
48		Sodium oxoiodate	
49		Antimony pentafluoride	
50			Ammonium dichromate





Nomenclature of oxoacids & oxosalts

	Formula	Stoichiometric name	Traditional
1	Ba(ClO ₂) ₂		
2	H ₄ SiO ₄		
3	Fe ₂ (CO ₃) ₃		
4	Cu(ClO ₄) ₂		
5	Pb(NO ₃) ₂		
6	K ₂ SO ₃		
7	Sr(BO ₂) ₂		
8	HIO		
9	Co(MnO ₄) ₃		
10	MgSO ₂		
11	H ₂ CrO ₄		
12	BeSO ₄		
13	HPO ₃		
14	Sn(IO ₄) ₂		
15	PtCr ₂ O ₇		
16	Pb(NO ₃) ₄		
17	H ₃ BO ₃		
18	Cs ₃ PO ₄		
19	Al(ClO ₃) ₃		
20	AuNO ₂		
21	Ag ₄ P ₂ O ₇		
22	Bi ₂ (SO ₄) ₃		
23	HgClO		
24	H ₃ PO ₃		
25	K ₂ Cr ₂ O ₇		
26			Sodium perchlorate
27			Bismuth (III) phosphate
28			Gold (I) nitrate
29			Silver carbonate
30			Titanium (IV) sulphate
31		Lead tetrakis(trioxidoiodate)	
32			Calcium chlorate
33			Magnesium borate
34			Tin (II) nitrite
35			Strontium hypochlorite
36			Aluminium sulphite
37		tetrahydrogen(tetraoxidosilicate)	
38			Iron (II) manganate
39			Nickel (III) metasilicate
40			Lithium hyposulphite
41			Cesium chromate
42			Zinc bromite
43			Platinum (IV) dichromate
44		Hydrogen(dioxidoiodate)	
45			Ammonium disulphate
46			Barium metaphosphate
47			Potassium permanganate
48			Mercury (II) bromate
49			Diphosphoric acid
50			Cadmium periodate





Chemical reactions

1. Find the number of molecules of carbon dioxide and number of atoms of oxygen contained in a sample of 0.5 kg of carbon dioxide. Atomic masses: carbon: 12, oxygen: 16

Sol: $6,8 \cdot 10^{24}$ molecules; $1,37 \cdot 10^{25}$ atoms

2. Determine the number of molecules of ammonia and number of atoms of hydrogen in 100 g of ammonia. What is its volume at 720 mm Hg and 35° C?

Sol: $3,54 \cdot 10^{24}$ molecules; $106 \cdot 10^{25}$ atoms, 157 litres

3. A tennis ball contains about 40 g of sulphur hexafluoride. What is the number of moles of gas stored in the ball? What is the pressure of the gas considering its volume is 300 cm³ at 20° C?

Sol: 0,27 moles; 21 at

4. A butane (C₄H₁₀) gas cylinder contains 5 kg of gas. Determine the number of moles of butane and the number of molecules within the cylinder. What is the volume occupied by the gas when it is released at 700 mm Hg and 20 ° C?

Sol: 86,2 moles; $5,2 \cdot 10^{25}$ molecules; 2250 l

5. We solve 30 g of sodium chloride in 200 ml of solution. What is the molar concentration? What is the new molarity when we add half a litre of water?

Sol: 2,56 M; 0,68 M

6. What is the mass of copper (II) sulphate pentahydrate (CuSO₄·5H₂O) required to prepare 1.5 l of solution 10⁻³ M?

Sol: 0,37 g

7. What is the mass of nitric acid required to prepare 600 ml of a solution 0,6 M?.

Sol: 0,36 moles = 22 g

8. Magnesium hydride reacts with water and yields magnesium hydroxide and molecular hydrogen. Write and balance the chemical equation. Consider we throw 20 grams of magnesium hydride into water. What is the number of moles and molecules of water required for the reaction?. What is the mass of magnesium hydroxide produced in the reaction?. What is the volume of hydrogen, measured at 15° C and 730 mm Hg released in the reaction?

Sol: 1,54 moles; $9,63 \cdot 10^{23}$ molecules; 44,6 g; 38 l

9. Calcium hydride reacts with water and yields calcium hydroxide and hydrogen. Write and balance the chemical equation. Consider we throw 25 grams of calcium hydride into water. What is the number of moles and molecules of water required for the reaction?. What is the mass of calcium hydroxide produced in the reaction?. What is the volume of hydrogen, measured at STP, released in the reaction?

Sol: 1,2 moles; $7,2 \cdot 10^{23}$ molecules; 44 g; 27 l

10. Calcium carbide, CaC₂, reacts with water and yields calcium hydroxide and ethine (C₂H₂). Write and balance the chemical equation Calculate the mass of water required to produce 200 g of ethine. What is the volume occupied by this gas at 25° C and 0,97 at?

Sol: 277,2 g; 193.8 l

11. Sodium carbonate reacts with hydrochloric acid and produce carbon dioxide, sodium chloride and water. Determine the volume of a solution of hydrochloric acid 0,6 M required to react with 4.2 g of sodium carbonate.

Sol: 132 ml

12. Consider the combustion of 10,4 litres of acetylene (ethine, C₂H₂) at STP. Determine the volume of oxygen at STP required to complete its combustion. What is the volume of air required for the reaction, measured at 17° C y 700 mm? Air consists of 20 % of oxygen and 80 % of nitrogen

Sol: 26 l; 150 l

13. The combustion of 3 tones of anthracite (coal) which has 3 % of sulphur impurity, released to the atmosphere sulphur dioxide. Determine the mass of sulphur dioxide released and its volume at STP

Sol: 180 kg; 63 m³





Chemical reactions

14. A commercial solution of hydrogen peroxide contains 3 % of solute and its density is $1,03 \text{ g.cm}^3$. Determine its molar concentration. Hydrogen peroxide produces water and oxygen. Write and balance the chemical equation. What is the volume of oxygen, measured at STP, released after the reaction of 100 ml of solution? **Sol: 0.88 M; 1,02 l**

15. Determine the density of chlorine at 30° C and 700 mm Hg **Sol: 2,63 g/l**

16. Determine the mass of carbon dioxide that we have to release from a 25 l-container at 6 at and 20° C so as to reduce its pressure to 2 at at the same temperature **Sol: 183 g**

17. Determine the mass and the number of molecules of butane, C_4H_{10} , stored in a gas cylinder whose volume is 20 l at 2 at and 20° C **Sol: 95 g; 10^{24}**

18. A solution of glycerin ($\text{C}_3\text{H}_8\text{O}_3$) has 56 % of solute and its density is $1,1 \text{ g/cm}^3$. Determine its molar concentration **Sol: 6,7 M; 56,1 y 43,9 %**

19. A five litre iron container is filled with air, which has 21 % of oxygen and 79 % of nitrogen, at 239° C and 0.1 at. Considering that all the oxygen reacts with iron to produce iron (II) oxide, determine the mass of iron (II) oxide produced in the reaction. Determine the final pressure in the container and the temperature required to reach a pressure equals to 0,1 at **Sol: 0,36 g; 0,079 at; 650 K**

20. The combustion of 3 g of anthracite (coal) produces 5,3 l of carbon dioxide measured at STP. Determine the mass of carbon in the sample and its mass percentage **Sol: 2,83 g; 94,6 %**

21. The roasting of zinc sulphide with hot oxygen produces zinc oxide and sulphur dioxide. What is the mass of sulphur dioxide produced by the roasting of 50 g of zinc sulphide? What is the volume of oxygen required measured at 1 at and 160° C ? **Sol: 32,8 g; 27,3 l**

22. The reaction between 100 g of zinc and hydrochloric acid yields zinc chloride and hydrogen. What is the mass of hydrochloric acid required for the reaction? What is the volume of commercial solution 37 % of acid and density $1,18 \text{ g/ml}$ required in the reaction? What is the mass of zinc chloride obtained? What is the volume of hydrogen at STP? **Sol: 111,6 g; 256 ml; 209 g; 34,2 l**

23. Aluminium combines to nitric acid and yields aluminium nitrate and hydrogen. Write and balance the chemical equation. Consider we want to solve 4.5 g of aluminium, Determine the volume of nitric acid solution, which is 69 % and whose density is $1,41 \text{ g/ml}$, required for solving 4,5 g of aluminium. What is the molar concentration of the solution?. What is the volume of hydrogen released in the reaction, measured at 1 at and 23° C ? **Sol: 32,4 ml; 15,4 M; 6,2 l**





Atomic structure & chemical bond

1. Determine the group and period of the elements whose atomic number are shown as follows: 15, 20, 35 y 55. What are their most frequent oxidation numbers?
2. Determine the electron structure of the following elements according to their place in the periodic table: potassium, aluminium, tin and bromine. What are their most frequent oxidation numbers?
3. Based on the following atomic numbers: $Z = 7$, $Z = 13$ y $Z = 15$, which elements are in the same group? Which elements do share the same period?
4. Write the electron structure of the elements whose atomic numbers are 4, 11, 17 and 33. Determine the group of each element, showing which are metals or nonmetals. What are their most frequent oxidation numbers?
5. A valence shell electron structure is $4s^2 4p^3$. According to this, determine its place in the periodic table. Determine its atomic number and state the most frequent oxidation numbers of the element
6. Elements A, B, C y D have atomic numbers 3, 10, 20 and 35, respectively. Write the electron structures of each one and show its place in the periodic table
7. Determine which of the following statements are true or false and give a reasoned answer
 - a) the structure $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$ is the ground state of an atom
 - b) the electronic configuration $1s^2 2s^2 2p^7 3s^1$ doesn't exist
 - c) the structures $1s^2 2s^2 2p^6 3s^1 3p^1$ and $1s^2 2s^2 2p^5 2d^1 3s^2$ are two different configurations of the same atom
 - d) the configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$ refers to an alkaline-earth element
8. Given the elements which have the following atomic numbers: 19, 23 and 48: write their electron structures; explains if the element ($Z = 30$) is placed in the same group or period of the others
9. Write the electronic configuration in the ground state of the following atoms or ions: N^{3-} , Mg^{2+} , Cl^- , K y Fe. Which species are isoelectronic?
10. Write Lewis structures for the following molecules: PF_3 , CH_2O and N_2 . Nitrogen and phosphorus are in the group 15; carbon in the 14, oxygen in 16 and fluorine in the 17
11. Write Lewis structure for the following molecules: CH_3Cl (chloroform), NH_3 , HNO_2 and H_2CO_3 . Carbon is in group 14 and Nitrogen in 15
12. Write Lewis structure for the following molecules: CO_2 , SO_3 , BF_3 and SO_2 . Carbon is in group 14, nitrogen in 15 and sulphur in 16

