

STAMPING ON THE CARBON FOOTPRINT EXAMPLE QUESTIONS

TRAVEL

1 | medium level

How many kilograms of CO₂ per kilometre are produced during the 51 matches of the 2016 UEFA European Championship by the fans (40 000 per match) if

- a) ¼ is coming by train, ¼ by bike, ¼ by bus, ¼ by plane?
- b) ½ is coming by car, ¼ by bike, ¼ by bus?
- c) ¼ is coming by train, ¼ by car, ½ by plane?

Answer for a):

Number of fans for each mode of transportation:

$$51 \cdot 40\,000 = 2\,040\,000 / 4 = 510\,000$$

Travel by train: $510\,000 \cdot 122.5 \text{ g/km} = 62\,475 \text{ kg/km}$

Travel by bus: $510\,000 \cdot 62.5 \text{ g/km} = 31\,875 \text{ kg/km}$

Travel by train: $510\,000 \cdot 395 \text{ g/km} = 201\,450 \text{ kg/km}$

Total CO₂: $295\,800 \text{ kg/km one way}$

→ $591\,600 \text{ kg/km two way}$

2 | easy level

2 | 1 How many trees do you need to plant to equalise within one year

- a) 598 000 kilograms of CO₂ per kilometre
- b) 300 000 kilograms of CO₂ per kilometre
- c) 100 000 kilograms of CO₂ per kilometre

produced by the fans? If a tree occupies an area of 25 m², how many football fields are used?

Answer for a):

Number of trees: $598\,000 \text{ kg} / 46 \text{ kg} = 13\,000$

Trees per football field: $(105 \text{ m} \cdot 68 \text{ m}) / 25 \text{ m}^2 = 287$

Number of football fields: $13\,000 / 287 = 45$

→ For every kilometre travelled you need to plant the area of 45 football fields with trees to absorb the produced CO₂ within one year.

2 | 2 How many kilograms of CO₂ do you produce to arrive at the stadium to watch the match of your favourite football team? Compare various modes of transportation such as car, train, bus and plane, and travel distances such as 500 km, 1000 km and 2000 km. Remember to calculate two ways and that in the car you could be alone or sharing the ride with others.

Example answer for a full car travelling 1000 km one way:

travel distance one way · 2 · amount of CO₂ per km

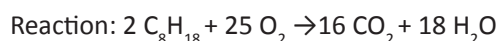
$$= 1000 \text{ km} \cdot 2 \cdot 50 \text{ g/km} = 100\,000 \text{ g} = 100 \text{ kg}$$

3 | higher level

Calculate the amount of carbon dioxide [kg] produced by the combustion of 1 kg of various fuels using the balanced reaction and data on the information card.

a) petroleum b) methane c) LPG d) ethanol

Answer for a):



Molecular weight (W): C₈H₁₈ = 114 g/mol; CO₂ = 44 g/mol

$$n = m/W$$

(n: amount of substance [mol], m: mass [g])

$$n_{\text{petroleum}} = m_{\text{petroleum}} / W_{\text{petroleum}} = 1000 \text{ g} / (114 \text{ g/mol}) = 8.77 \text{ mol}$$

Number of moles of CO₂ produced by the reaction:

$$n_{\text{petroleum}} / 2 = n_{\text{CO}_2} / 16$$

$$n_{\text{CO}_2} = 8.77 \text{ mol} \cdot 16/2 = 70 \text{ mol}$$

$$\rightarrow m_{\text{CO}_2} = n_{\text{CO}_2} \cdot W_{\text{CO}_2} = 70 \text{ mol} \cdot 44 \text{ g/mol} = 3088 \text{ g} = 3.1 \text{ kg}$$

LIGHT

1 | easy level

1 | 1 How much does it cost to illuminate the playing field during a match if a total of

a) 1280 kWh b) 3500 kWh c) 640 kWh

is consumed and 1 kWh costs €0.06?

Answer for a):

$$1280 \cdot €0.06 = €76.8$$

1 | 2 Calculate your daily electrical consumption at home with the formula

$$(number\ of\ persons \cdot 500 \text{ kWh} + 500 \text{ kWh}) / 365$$

and find out how many households consume the energy equivalent of the illumination of one playing field (1280 kWh).

Assume the household consists of

a) 4 b) 2 c) 8

persons.

Answer for a):

daily consumption: $2500 \text{ kWh} / 365 = 6.8 \text{ kWh}$

number of households: $1280 \text{ kWh} / 6.8 \text{ kWh} \approx 188$

→ 188 four-person households consume per day the same amount of energy needed to illuminate one playing field.

1 | 3 Calculate the luminous efficacy for an incandescent lamp, a fluorescent one and an LED one.

Answer:

$$L = E / P$$

L : luminous efficacy [lm/W]

E : luminous flux [lm]

P : power [W]

incandescent light: $900 \text{ lm} / 60 \text{ W} = 15 \text{ lm/W}$

fluorescent light: $900 \text{ lm} / 15 \text{ W} = 60 \text{ lm/W}$

LED light: $900 \text{ lm} / 13 \text{ W} \approx 69 \text{ lm/W}$

2 | higher level

2 | 1 The energy produced in a power station is transferred and distributed to customers but only a part of this energy is available. In Italy the loss of energy in the distribution grid is about 10.8%. If the yearly energy used at home is about

a) 50 000 kWh b) 25 000 kWh c) 10 000 kWh

calculate the energy lost and transmitted from the power station. What do we pay for this inefficiency if 1 kWh costs €0.06.

Answer for a):

Energy transmitted: 100%

Energy used in household: 89.2%

$$50\,000 / 89.2 = x / 100$$

→ energy transmitted in one year: $x = 56\,054 \text{ kWh}$

energy lost in one year:

$$56\,054 \text{ kWh} - 50\,000 \text{ kWh} = 6054 \text{ kWh}$$

$$6054 \cdot €0.06 = €363.24$$

2 | 2 What is the amount of coal needed to power a 60 Watt ($1 \text{ W} = 1 \text{ J/s}$) incandescent light bulb for one hour? The efficiency of a thermal power plant is 35.0% and in the distribution grid 10.0% is lost as heat. The chemical energy of coal is 32.8 kJ per 1.00 g burned.

Answer:

Energy left from electricity generation:

$$32.8 \text{ kJ/g} \cdot 0.35 = 11.5 \text{ kJ/g}$$

Energy left after distribution grid:

$$11.5 \text{ kJ} - (11.5 \text{ kJ} \cdot 0.10) = 10.4 \text{ kJ/g}$$

Burning time for bulb for coal:

$$(10\,400 \text{ J/g}) / (60 \text{ J/s}) = 173 \text{ s/g}$$

Amount of coal needed to power the bulb for one hour:

$$3600 \text{ s} / (173 \text{ s/g}) = 20.8 \text{ g}$$

2 | 3 Burning 1.0 kg of petrol in a power plant leaves you only 31.5% of the primary energy of approximately 15 087 kJ. How many grams of petrol are really converted into light for

a) an incandescent light bulb

b) a fluorescent light bulb

c) an LED

Answer :

Amount of petrol left after electricity generation and loss in

distribution grid:

$$1 \text{ kg} \cdot 0.315 = 0.315 \text{ kg} = 315 \text{ g}$$

Amount of petrol turned into light for

incandescent light bulb: $315 \text{ g} \cdot 0.02 = 6.3 \text{ g}$

fluorescent light bulb: $315 \text{ g} \cdot 0.08 = 25.2 \text{ g}$

LED: $315 \text{ g} \cdot 0.11 = 34.65 \text{ g}$

FOOD

1 | easy level

1 | 1 What is the amount of kilocalories a football player should eat for breakfast preparing for a game later in the morning?

a) 2000 kcal b) 1000 kcal c) 750 kcal d) 500 kcal

Correct answer: c)

1 | 2 What would be the best packaging for drinks in the stadium?

a) aluminium b) glass c) cellulose d) plastic

Correct answer: b)

1 | 3 The sustainability of food depends on its production cycle. Look at the information card to find carbon and water footprint of some foods, calculate how many kilograms of CO_2 equivalent are saved consuming 1 kg of potatoes per week instead of beef. (Calculate the same for various foods such as rice or eggs)

Answer:

CO_2 equivalent produced for

$$- 1 \text{ kg potatoes: } 0.1 \text{ kg} \cdot 2 = 0.2 \text{ kg}$$

$$- 1 \text{ kg beef: } 3.16 \text{ kg} \cdot 2 = 6.32 \text{ kg}$$

$$\rightarrow \text{CO}_2 \text{ equivalent saved: } 6.32 \text{ kg} - 0.2 \text{ kg} = 6.12 \text{ kg}$$

1 | 4 The sustainability of food depends on its production cycle. Look at the information card to find carbon and water footprint of some foods, calculate how many liters of water are saved consuming 1 kg of potatoes per week instead of beef. (Calculate the same for various foods such as rice or eggs)

Before you calculate guess how many 1.5 L bottles of water you would save? (10 000, 5000, 15 000 or 1000)

Answer:

Size of H_2O footprint for

$$- 1 \text{ kg potatoes: } 144 \text{ L} \cdot 2 = 288 \text{ L}$$

$$- 1 \text{ kg beef: } 7751 \text{ L} \cdot 2 = 15\,502 \text{ L}$$

$$\rightarrow \text{water saved: } 15\,502 \text{ L} - 288 \text{ L} = 15\,214 \text{ L}$$

2 | higher level

The supporters eat a lot of sweets, such as popcorn. The energy of the food may be used to stand up and down from your seat. Popcorn contains 1721 joule per 100 grams. How many Mexican waves can 20 000 supporters do if they eat one portion of popcorn (100 g) each and a person of 70 kg

needs on average 450 joules to stand up/down?

Answer:

Mexican waves for each supporter:

1721 J / 450 J \approx 3.80

→ Each supporter can do nearly 4 Mexican waves with the energy of 100 g popcorn.

NOISE

1 | medium level

1 | 1 The power of a loudspeaker used during the game is about 0.20 W through a surface of 6 m². What is the intensity of the sound? What is the level of acoustic pressure produced?

Answer:

Intensity of the sound:

$$I = P/A = 0.20/6 \text{ W/m}^2 = 0.033 \text{ W/m}^2$$

Level of acoustic pressure:

$$L = 10 \log I + 120$$

$$L = 119 \text{ dB}$$

1 | 2 If one supporter shouts „goal“, the level of acoustic pressure is $L = 80 \text{ dB}$. What is the acoustic pressure and the intensity for 1000 supporters?

Answer:

Level of acoustic pressure L_n [dB] for n sources

$$L_n = 10 \log n + L_1$$

$$L_1 = 80 \text{ dB}$$

$$L_{1000} = (10 \log 1000 + 80) \text{ dB}$$

$$L_{1000} = 110 \text{ dB}$$

1 | 3 The WHO (World Health Organization) defines the acoustic threshold of health risk at 85 dB and the acoustic threshold of pain at 120 dB. How large is the increase of sound intensity?

Answer:

$$L_1 = 85 \text{ dB} \rightarrow I_1 = 3.2 \cdot 10^{-4} \text{ W/m}^2$$

$$L_2 = 120 \text{ dB} \rightarrow I_2 = 1.0 \text{ W/m}^2$$

$$\rightarrow I_2/I_1 = 1/(3.2 \cdot 10^{-4}) = 3125$$

1 | 4 How many metres do you have to move away if a sound is measured at 120 dB at a distance of 3 m if you want to be safe at 65 dB?

Answer:

$$L_1 = 65 \text{ dB} \rightarrow I_1 = 3.2 \cdot 10^{-6} \text{ W/m}^2$$

$$L_2 = 120 \text{ dB} \rightarrow I_2 = 1.0 \text{ W/m}^2$$

$$I_1/I_2 = (d_2)^2/(d_1)^2$$

$$d_2 = \sqrt{(3^2/3.2 \cdot 10^{-6}) \text{ m}}$$

$$d_2 = 1677 \text{ m}$$

1 | 4 Every time you double the distance to a source the acoustic pressure level decreases by 6 dB. Is this correct?

Answer:

$$d_2 = 2 d_1$$

$$\rightarrow I_1/I_2 = (2 d_1)^2/(d_1)^2$$

$$\rightarrow I_2 = \frac{1}{4} I_1$$

$$\Delta L = L_2 - L_1 = (10 \log (\frac{1}{4} I_1) + 120) \text{ dB} - (10 \log I_1 + 120) \text{ dB}$$

$$= 10 \cdot (\log (\frac{1}{4} I_1) - \log I_1) \text{ dB}$$

$$= -10 \text{ dB} \cdot \log 4 = -6.021 \text{ dB} \approx -6 \text{ dB}$$

2 | easy level

2 | 1 During the halftime break of a game, there is often music. How long does it take for the sound to travel from one side of the field to the other side through air (distance about 110 m)? What would be the travel time in vacuum?

Answer:

Speed of sound in air: $v = 343 \text{ m/s}$

$$\Delta t = d/vt = 110 \text{ m} / (343 \text{ m/s}) = 0.32 \text{ s}$$

There is no sound in vacuum.

2 | 2 What is the threshold of acoustic pressure that hurts your ears?

a) 120 dB b) 100 dB c) 80 dB d) 150 dB

Correct answer: a)

GRASS & WASTE

1 | easy level

1 | 1 Using 500 kg of compost from food to fertilize the football pitch, how many kilograms of nitrogen N, phosphorus P, and potassium K are distributed in the soil?

Answer:

$$\text{N: } (9 \text{ kg/ton}) \cdot \frac{1}{2} \text{ ton} = 4.5 \text{ kg}$$

$$\text{P: } (3.1 \text{ kg/ton}) \cdot \frac{1}{2} \text{ ton} = 1.55 \text{ kg}$$

$$\text{K: } (5.4 \text{ kg/ton}) \cdot \frac{1}{2} \text{ ton} = 2.7 \text{ kg}$$

1 | 2 Decide if the following compounds are carbon or nitrogen rich using the information card.

Compounds: branches, fruits, pine cones, cardboard, dry leaves, grass, vegetables, straw, tea bags, coffee, cork.

Answer:

nitrogen rich

grass, vegetables, fruits,
tea bags, coffee

carbon rich

branches, cork, straw, pine
cones, cardboard, dry
leaves

1 | 3 If you want to prepare 1000 g of compost, what is, on average, the amount of water needed?

Answer: $1000 \text{ g} \cdot 0.55 = 550 \text{ g}$

1 | 4 If we cut the grass (2.5 cm) of a stadium (120 m x 60 m), what will the volume of the cut grass be in cubic metres?

Answer: 180 m^3

1 | 5 How many m^3 of garbage will be produced by the use of 7,000 paper cups if each one occupies a volume of 0.25 dm^3 .

Answer: 1.75 m^3

2 | medium level

2 | 1 To fertilize the playing field ($105 \text{ m} \times 68 \text{ m} = 7140 \text{ m}^2$) and the areas surrounding the stadium you can use the compost produced by the pruning and food waste. Calculate the amount of compost from greens needed to fertilize the playing field and to provide sufficient nitrogen for the soil.

Answer:

nitrogen needed: 35 g/m^2

nitrogen needed for the playing field:

$$(35 \text{ g/m}^2) \cdot 7140 \text{ m}^2 = 250 \text{ kg}$$

nitrogen content of compost from greens: 5.5 kg/ton

compost needed in total:

$$(250 \text{ kg}/5.5 \text{ kg}) \cdot 1000 \text{ kg} = 45.5 \text{ t}$$

2 | 2 How long is the ideal grass on a soccer field? Give reasons.

a) 1mm b) 10cm c) 5cm d) 20cm

Correct answer: c)

2 | 3 A toilet roll is 60 m long and weighs 190 g. You may recycle the toilet paper and use the energy of the combustion (15 MJ/kg) to heat the water of the showers. How many toilet rolls are necessary to warm up $100 \text{ L} = 100 \text{ kg}$ water from 10°C to 50°C ?

Answer:

The specific heat of water is $4.186 \text{ J/(g} \cdot ^\circ\text{C)}$ for $1 \text{ g} = 1 \text{ mL}$ water with a change in temperature of 1°C .

Energy needed to heat up 1 g water by 40°C :

$$4.186 \text{ J/(g} \cdot ^\circ\text{C}) \cdot 40^\circ\text{C} \cdot 1 \text{ g} = 167.44 \text{ J}$$

Energy needed to heat up 100 kg water by 40°C :

$$167.44 \text{ J} \cdot 100\,000 = 16\,744 \text{ kJ}$$

Number n of toilet rolls needed:

$$15\,000 \text{ kJ} / 1 \text{ kg} = 16\,744 \text{ kJ} / (n \cdot 190 \text{ g})$$

$$n \cdot 190 \text{ g} = 1.11 \text{ kg}$$

$$n = 1110 \text{ g}/190 \text{ g}$$

$$n \approx 5.84$$