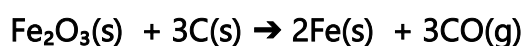


Item 1

A Ugandan steel manufacturing company in Jinja Industrial Park has just received a firm export order for 50 tonnes of iron to be delivered within the next production cycle. The company uses locally sourced iron ore that is only 75 % Fe₂O₃ by mass (the remaining 25 % is inert impurity). The reduction process relies on charcoal (assumed pure carbon) in a blast-furnace-type operation according to the simplified overall reaction:



The procurement officer must decide how much charcoal to purchase, while the environmental compliance officer is concerned about the large volume of carbon dioxide that will be emitted and the resulting carbon tax liability (2 500 UgX per tonne of CO₂ released). Management is under pressure to keep production costs low and meet environmental regulations before the order can be fulfilled.

The production manager has invited your A-Level Chemistry class to review the process data and provide a full technical evaluation ahead of the urgent procurement and compliance meeting scheduled for next week. As the head of your Chemistry study group, the teacher has selected you to produce a technical report advising the procurement and environmental compliance officer.

Task

Prepare a technical report for the procurement and environmental compliance team.

Item 2

A copper refining and export company is facing a major quality-control crisis. International buyers have questioned the purity and isotopic composition of recent copper shipments. The company's analytical laboratory has used a mass spectrometer on a representative sample and provided the following isotopic data for copper:

| Isotope | Isotopic mass |
|------------------|---------------|
| ⁶³ Cu | 62.93 |
| ⁶⁵ Cu | 64.93 |

Management needs a full scientific explanation of how the mass spectrometer works, in determining the accurate relative atomic mass of an element; how the percentage abundances can be determined when the relative atomic mass is known, and an evaluation of the strengths and limitations of using mass spectrometry for routine industrial quality control before the next shipment is approved.

Task

As a student of Chemistry, analyse this situation and provide a write up of a technical report for the quality-control and export team of the company.

Item 3

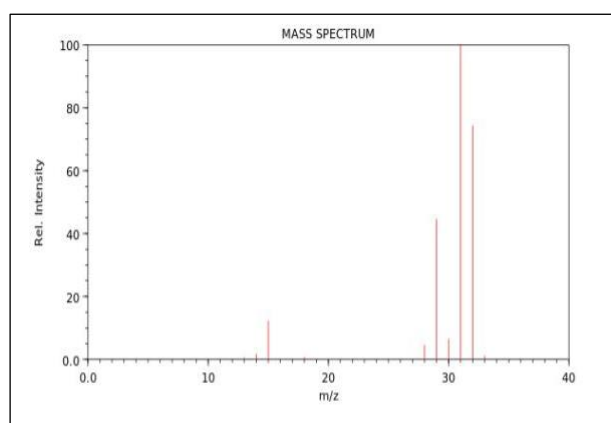
It has been established by the physical sciences that some elements like sodium have identical atoms of mass 23u in nature while others like magnesium and lithium do not. Those of magnesium have mass, 23.99, 24.99 and 25.98 and occur in a natural sample at rates of 78.99%, 10.00% and 11.01% respectively.. The average atomic mass of lithium is 6.94 and its atoms have masses of 6 and 7. To Nahabwe Justine, a new comer to your class, this poses a problem in her understanding. She wonders (i) how does it happen that an element can have different atoms and (ii) how then can the mass of one atom of an element with different atoms be worked out. She also insists that in a natural sample, all atoms whether identical or not must occur at the same rate.

Task

As a student of Chemistry help Justine understand by writing a brief technical write up that answers Justine's questions.

Item 4

The Kampala Metropolitan Police recently raided an illegal bar in the suburbs, seizing barrels of homemade alcohol being sold as "local gin." Laboratory analysis revealed the presence of an adulterant liquid Q (suspected to be methanol) mixed with ethanol. The police forensic lab performed mass spectrometry on Q, producing the following fragmentation pattern.



The forensic team is unfamiliar with interpreting mass spectra and has asked for chemistry student assistance to identify Q quickly, explain the fragmentation, and recommend urgent public health measures to prevent further poisoning. Most of the

team does not appreciate how the mass spectrometer works or why it is valuable for identifying dangerous adulterants in illicit alcohol. The challenge is to use the spectrum data to confirm Q's identity, explain the key fragments, and propose solutions to stop the distribution of adulterated alcohol while educating the public and authorities on detection methods.

Task

As a chemistry student assisting the police forensic team, write a concise explanatory report you would submit to the officers and health officials and community leaders.

Item 5

A youth group is working out the formulation of a pH stabilizer for male hormone enhancement juice they are to put on the market. They plan to use an ethanoic acid – sodium ethanoate buffer. To prepare this buffer, they are to first be sure about the quality of an ethanoic acid solution (vinegar) they bought from downtown Kampala. The labels on the cans indicate that the vinegar is 0.05M. To standardise the vinegar, they plan to carry out an acid – base titrimetry using sodium hydroxide solution they have had in storage for over a month and methyl orange as indicator.

Tasks

- a) Explain to the youth group, the shortcomings if any of using their sodium hydroxide solution as a reagent in this situation and propose any mitigation measures you think useful.
- b) In their titration, they found that 25.0 cm³ of the 0.025 M sodium hydroxide required 18.60 cm³ of the vinegar solution for the titration to reach endpoint. Assess the accuracy of the labels on the vinegar cans, clearly explaining your method.

Item 6

To do a quality control on a batch of calcium oxide claimed to be 99% pure by the supplier, bought by a poultry farm to be used as a chicken feed additive, the farm nutritionist has proposed an acid – base titrimetry on a sample of the calcium oxide following the procedure below:

Accurately weigh 1.4g of the calcium oxide and dissolve them in 100 cm³ of a 1M hydrochloric acid. Make up the solution to 250 cm³ in a volumetric flask using distilled water. Titrate the resultant solution against a 0.2M sodium hydroxide solution using phenolphthalein indicator.

Tasks

- a) Explain the method proposed by the nutritionist showing why it works.

- b) If in the titration, 20.0 cm³ of the sodium hydroxide required 17.7 cm³ of the resultant solution in the flask, assess the claims of the supplier and advise accordingly

Item 7

In the small chemical factory in that produces sodium-based compounds for water softening and local soap making, the production manager has received two unknown elemental samples labelled X and Y from a new supplier. The supplier provided only limited information: "Element X has its last electron entering the 4s orbital" and "Element Y has an atomic number of 17 and shows high reactivity with sodium metal." The factory must decide quickly which element can be safely used in their process without causing violent reactions or explosions when sodium is present. Misidentification could lead to equipment damage, worker injury, or costly production halts. The manager has asked a chemistry student from the nearby school to prepare a short technical report for the next safety meeting so the team understands the identity, location in the periodic table, and reactivity risks of both elements, and can make an informed decision on safe handling and use.

Task

As the chemistry student advising the chemical factory safety team, write a technical report you would present at the next planning meeting, using the supplier's information to determine the electronic configurations of elements X and Y, identify their groups and periods in the periodic table, explain why element Y reacts vigorously with sodium using electronic configurations, and recommend safe handling procedures and the most suitable element for the factory's sodium-based processes.

Item 8

A truck carrying an industrial radiography source (iridium-192) overturned on the Kampala–Masaka highway near Lukaya town at 10:00 a.m. The container cracked, releasing radioactive material onto the roadside. The National Emergency Coordination Centre (NECC) quickly cordoned off the area and began monitoring activity levels every two hours to determine when the site can be safely accessed for cleanup and when the road can reopen.

The Uganda Atomic Energy Council (UAEC) has set a safe activity threshold for unprotected public access and initial cleanup operations at ≤ 50 counts per minute (cpm) at the accident site. Above this level, workers require full protective gear and limited exposure time; below it, normal traffic and residents can return with minimal risk.

Measured activity readings at the accident location are:

| Time after accident occurs (hours) | Activity (counts per minute) |
|------------------------------------|------------------------------|
| 0 | 1200 |
| 2 | 850 |
| 4 | 600 |
| 6 | 425 |
| 8 | 300 |

The NECC Director and District Police Commander have urgently contacted you, an independent radiation safety specialist from UAEC, for an expert assessment before the 6:00 p.m. press briefing and public announcement. They need to decide whether the activity will drop below the safe level of 50 cpm soon enough to allow partial reopening overnight or whether full closure must continue.

Task

Prepare a concise technical write up for the NECC Director that clearly shows your scientific treatment of the data and necessary advise.

END