PART Y Chemistry

21 The following organic reactions are carried out:

1 1-Chloropropane is warmed with aqueous sodium hydroxide.

2 Propan-1-ol is heated under reflux with excess acidified potassium dichromate(VI).

3 Propan-2-ol is heated under reflux with excess acidified potassium dichromate(VI).

4 Propene is heated with hydrogen gas over a nickel catalyst.

What is the order of boiling points of the major organic product from each of these reactions, from lowest to highest boiling point?

	lowest → highest boiling point
A	1, 2, 3, 4
B	1, 4, 3, 2
C	2, 1, 3, 4
D	2, 3, 4, 1
E	3, 4, 2, 1
F	3, 1, 2, 4
G	4, 3, 1, 2
H	4, 3, 2, 1

22 The equations for the complete combustion of ethanol (Reaction 1) and the complete combustion of propan-1-ol (Reaction 2) are:

Reaction 1: $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

Reaction 2: $C_3H_7OH + 4.5O_2 \rightarrow 3CO_2 + 4H_2O$

The standard energy change for Reaction 2 is 650 kJ mol^{-1} more exothermic than the standard energy change for Reaction 1.

Assume the following bond energy data:

bond	*bond energy* / kJ mol^{-1}
C – C	350
C – H	400
O – H	450
O=O	500

Using this data, what is the value of the bond energy for the C=O bond?

A 175 kJ mol^{-1}

B 425 kJ mol^{-1}

C 450 kJ mol^{-1}

D 650 kJ mol^{-1}

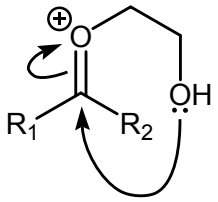
E 825 kJ mol^{-1}

F 900 kJ mol^{-1}

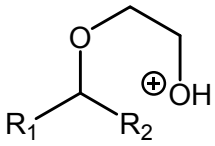
G 1050 kJ mol^{-1}

H 1650 kJ mol^{-1}

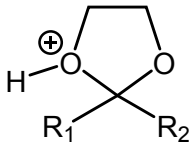
23 Part of an organic reaction mechanism is shown:



What is produced by this part of the mechanism?



A



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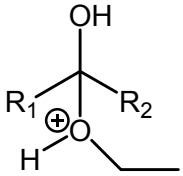

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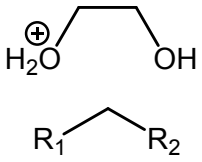

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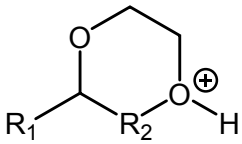

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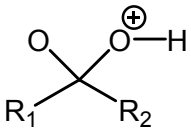

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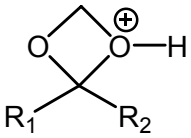

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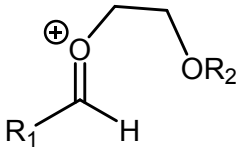
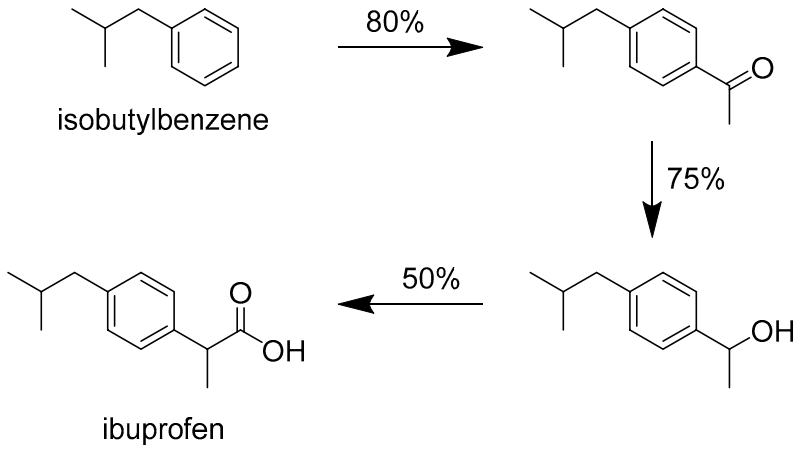


H

24 Ibuprofen is a common pain relief and anti-inflammatory drug. It is often sold in tablet form, each tablet containing 200 mg of the drug.

Ibuprofen can be synthesised from isobutylbenzene in a 3-stage process with the percentage yields for each step shown on the arrows:



6.7 g of isobutylbenzene is converted to ibuprofen to trial this process.

What is the maximum number of 200 mg ibuprofen tablets that can be manufactured?

(A_r values: H = 1; C = 12; O = 16)

A 10

B 15

C 20

D 33

E 40

F 50

25 The enthalpy change for neutralisation of one mole of sulfuric acid was determined experimentally.

Solutions of sodium hydroxide (2.00 mol dm^{-3}) and sulfuric acid (4.00 mol dm^{-3}) were used in the experiment. The initial temperature of both solutions was 20.0 °C.

40.0 cm^3 of the sodium hydroxide solution was placed into a well-insulated container. The sulfuric acid was added to the alkali until the solution was neutral. The maximum temperature reached was 40.0 °C.

Assume that the specific heat capacity of all aqueous solutions is x J g^{-1} $°C^{-1}$, and that the density of all solutions is 1.0 g cm^{-3}.

What is the value for the enthalpy change, in kJ mol^{-1}, for neutralisation of one mole of sulfuric acid?

(Assume that all heat is transferred to the solution and no heat is lost to the surroundings.)

A $-5.0x$ kJ mol^{-1}

B $-10.0x$ kJ mol^{-1}

C $-12.5x$ kJ mol^{-1}

D $-15.0x$ kJ mol^{-1}

E $-20.0x$ kJ mol^{-1}

F $-25.0x$ kJ mol^{-1}

G $-50.0x$ kJ mol^{-1}

H $-100x$ kJ mol^{-1}

26 An object is electroplated with a thin layer of chromium with a mass of 0.26 g, using a solution made up of CrO_3 dissolved in acid.

Assume that 1 mole of electrons carries a charge of **96 000** coulombs.

How long does it take, in minutes, to electroplate the object using a 12 A current?

(1 ampere (A) is a current of 1 coulomb per second. A_r value: Cr = 52)

A $\frac{2}{3}$ minutes

B 2 minutes

C 4 minutes

D $6\frac{2}{3}$ minutes

E 20 minutes

F 40 minutes

G 120 minutes

H 240 minutes

27 Water is classified as hard or soft depending on the concentration of calcium ions from dissolved salts. Water with a calcium ion concentration of less than 0.60 mmol dm^{-3} is soft.

Hard water, which has a calcium ion concentration greater than 0.60 mmol dm^{-3}, can be softened by the addition of washing soda, sodium carbonate decahydrate ($Na_2CO_3 \cdot 10H_2O$), to precipitate calcium carbonate.

A 10 dm^3 sample of water contains a total of 15 mmol calcium ions from dissolved salts.

What is the minimum mass of washing soda required to change the classification of this sample from hard to soft?

(A_r values: H = 1; C = 12; O = 16; Na = 23; Ca = 40. Assume that the only metal ions present in solution are calcium ions and there is no change of volume on the addition of the washing soda.)

A 0.26 g

B 0.41 g

C 0.95 g

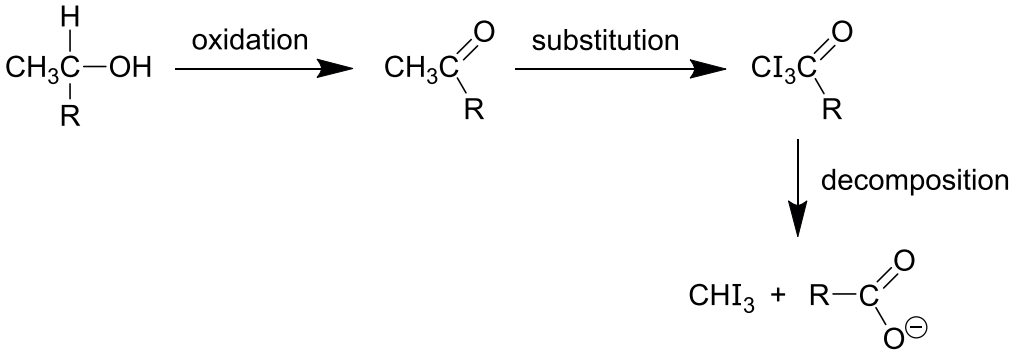
D 1.1 g

E 2.6 g

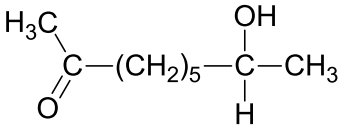
F 4.1 g

28 Triiodomethane is a pale-yellow solid with the formula CHI_3. It is formed when some organic compounds react with alkaline aqueous iodine.

When an alcohol reacts, the series of steps that take place during the reaction to produce the triiodomethane are:

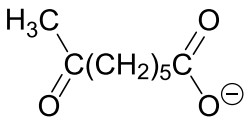


A compound with the following structural formula is completely reacted with excess alkaline aqueous iodine and the reaction mixture is then acidified with an excess of a dilute acid.



What is the final organic compound that is produced along with the triiodomethane?

A



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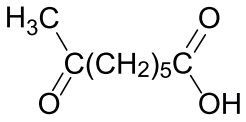

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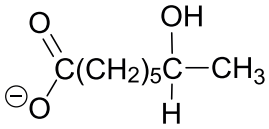

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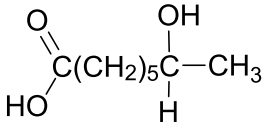

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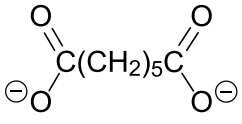

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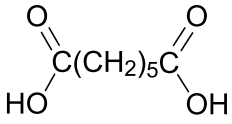
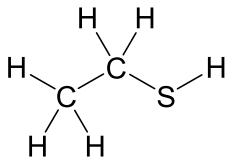


29 Ethanethiol, CH_3CH_2SH, is a foul-smelling gas that is added to natural gas to enable humans to detect gas leaks, which would otherwise not be noticed.



The minimum concentration of ethanethiol that a person can detect is 1.8×10^{-7} mg per cm^3 of air.

A gas leak happens in an empty room that has dimensions 20 m × 20 m × 3 m. Assume that the ethanethiol is spread evenly throughout the room.

If a person detected the gas leak, what is the minimum number of molecules of ethanethiol in the room to 1 significant figure?

(A_r values: H = 1; C = 12; S = 32. Avogadro's number = 6×10^{23})

A 2×10^{18}

B 2×10^{19}

C 2×10^{20}

D 2×10^{21}

E 2×10^{22}

F 2×10^{23}

G 2×10^{24}

H 2×10^{25}

30 Compounds P and T are isomeric hydrocarbons containing six carbon atoms. Compound T decolourises bromine water in a 1 **:** 1 molar ratio, whereas compound P does not react at all.

Compounds P and T both undergo free radical substitution reactions with chlorine in the presence of ultraviolet light to produce a number of mono-chlorinated products. One of these products is compound Q, formed from hydrocarbon P, and another is compound V, formed from hydrocarbon T.

- Q undergoes a substitution reaction with aqueous sodium hydroxide to form compound R. Compound R is oxidised with acidified potassium dichromate to form compound S which does not react with either Tollens' reagent or sodium carbonate solution.
- V undergoes a substitution reaction with aqueous sodium hydroxide to form compound W. Compound W is oxidised with acidified potassium dichromate to form compound X which causes bubbling when added to sodium carbonate solution.

Compound R reacts with compound X, in the presence of an acid catalyst, to form compound Y.

What is the relative molar mass (M_r) of compound Y?

(A_r values: H = 1; C = 12; O = 16)

A 180

B 184

C 196

D 200

E 210

F 214

31 Calcium and element X are two elements from Group 2 of the Periodic Table. Element X is one place above or one place below calcium in the group.

Some information about these two elements is:

element	*solubility of the element's anhydrous sulfate* / mol per 100 g of water
calcium	1.51×10^{-3}
X	7.11×10^{-5}

1.0 mol of XCO_3 is completely thermally decomposed. The solid residue is then completely reacted with dilute nitric acid, and the salt produced when in its anhydrous form has a mass of y.

Which row in the following table is correct?

(A_r values: N = 14; O = 16; Mg = 24; Ca = 40; Sr = 88)

	thermal stability of XCO_3	*value of* y
A	more thermally stable than $CaCO_3$	$y < 150$ g
B	less thermally stable than $CaCO_3$	$y < 150$ g
C	more thermally stable than $CaCO_3$	$y = 150$ g
D	less thermally stable than $CaCO_3$	$y = 150$ g
E	more thermally stable than $CaCO_3$	$y > 150$ g
F	less thermally stable than $CaCO_3$	$y > 150$ g

32 0.125 mol of a hydrocarbon undergoes complete combustion to form 22 g of carbon dioxide and 9 g of water.

What is the total number of isomers that can be represented by the molecular formula of this hydrocarbon?

(A_r values: H = 1; C = 12; O = 16)

A 2

B 4

C 5

D 6

E 7

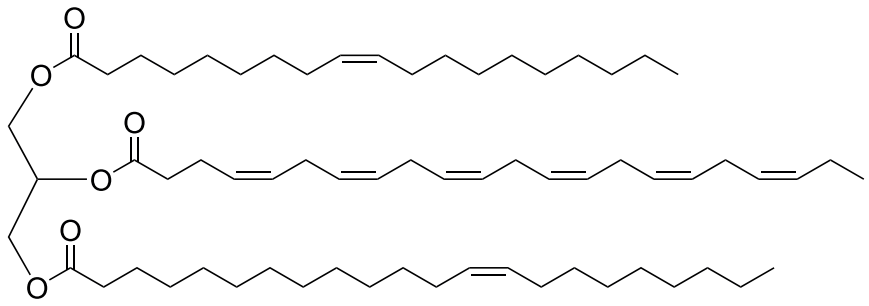
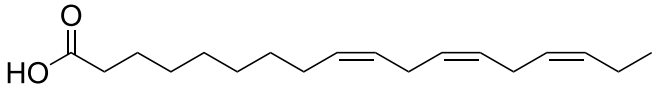
F 8

G 13

33 Unsaturation of fatty acids and lipids is measured by the iodine number.

The iodine number is the mass, in g, of iodine required to saturate all the C=C bonds in 100 g of the substance.

The structures of lipid P and fatty acid Q are shown:

lipid P (M_r = 1000)	
fatty acid Q (M_r = 278)	

Which of the following statements is/are correct?

1 One molecule of lipid P contains 112 hydrogen atoms.

2 The iodine number of lipid P is 203.2.

3 The iodine number of lipid P is greater than the iodine number of fatty acid Q.

(A_r value: I = 127)

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

34 A sample of copper(II) oxide is added to an excess of dilute sulfuric acid and warmed until no solid remains.

The solution is then electrolysed using inert electrodes.

During the first t_1 minutes, no bubbling is observed at the cathode, but the mass of the cathode increases by 0.635 g.

During the next t_2 minutes, bubbling is observed at the cathode. The volume of gas produced at the cathode is 120 cm^3.

Bubbling is observed at the anode throughout the electrolysis. The gas is collected and measured.

Which row identifies the gas produced at the **cathode**, and the total volume of gas produced at the **anode**, measured at room temperature and pressure?

(A_r value: Cu = 63.5. Assume that the volume of one mole of a gas is 24 dm^3 at room temperature and pressure.)

	*gas formed at the **cathode***	*total volume of gas produced at the **anode*** / cm^3
A	hydrogen	360
B	hydrogen	300
C	hydrogen	240
D	hydrogen	180
E	oxygen	360
F	oxygen	300
G	oxygen	240
H	oxygen	180

35 Concentrated sulfuric acid reacts with sodium iodide in three possible redox reactions, all of which produce iodine.

In these reactions, sulfuric acid is reduced to either $SO_2(g)$, or S(s) or $H_2S(g)$.

In an experiment, 0.3 g of sodium iodide reacts with excess concentrated sulfuric acid.

If exactly 0.1 g of this sodium iodide reacts in each of the three redox reactions, what is the total volume of sulfur-containing gases that are formed?

(A_r values: Na = 23; I = 127. Assume that one mole of a gas occupies 24 dm^3 at room temperature and pressure, and that none of the gases dissolve in the reaction mixture.)

A 10.0 cm^3

B 12.7 cm^3

C 16.0 cm^3

D 20.0 cm^3

E 24.0 cm^3

F 25.3 cm^3

G 32.0 cm^3

H 48.0 cm^3

36 The relative atomic mass of bromine is 80.0. Bromine has only two stable isotopes containing 44 and 46 neutrons.

The relative atomic mass of chlorine is 35.5. Chlorine has only two stable isotopes containing 18 and 20 neutrons.

Bromine and chlorine can form a compound $BrCl_3$. A sample of $BrCl_3$ was studied by mass spectrometry.

Which row in the table gives correct information about the low-resolution mass spectrum of $BrCl_3$?

(atomic numbers: Cl = 17; Br = 35)

	number of isotopic molecular ion peaks	*mass-to-charge ratio of the* ***most intense*** *peak(s)*
A	5	184
B	8	184
C	4	both 184 and 186
D	5	both 184 and 186
E	5	186
F	4	186.5
G	8	186.5
H	8	192

37 36 dm^3 of oxygen gas reacts completely with excess water and arsenic to form an acid only. This acid contains a single arsenic in oxidation state +3.

What mass of arsenic would be required?

(A_r values: As = 74.9; H = 1.0; O = 16. Assume that one mole of gas at room temperature and pressure occupies 24 dm^3.)

A 74.9 g

B 84.3 g

C 112.4 g

D 149.8 g

E 224.7 g

F 449.4 g

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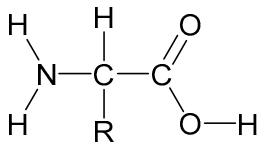
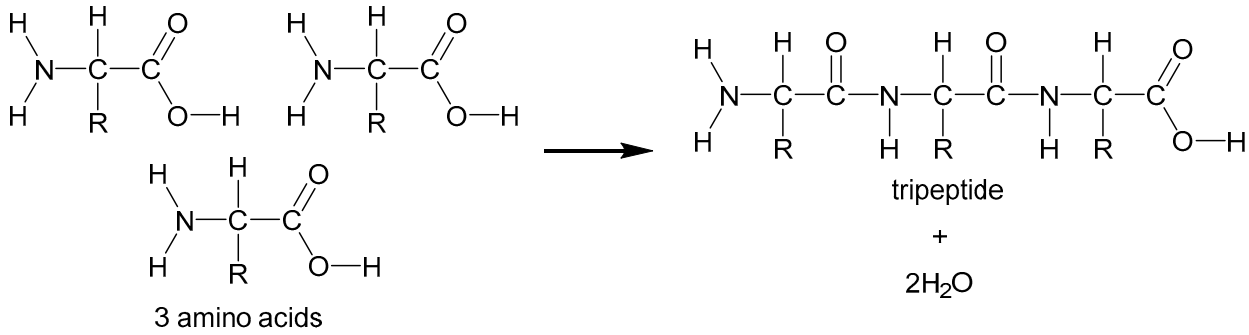
38 The general structure of an amino acid is:



The R group determines the identity of the amino acid.

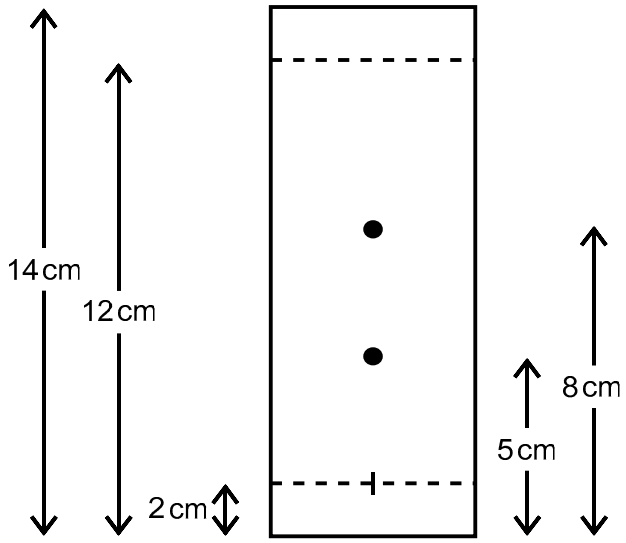
The equation for the reaction between three amino acids to make a tripeptide is shown.



The three amino acids may be the same or different.

A tripeptide is broken down into its three component amino acids and analysed using chromatography.

The chromatogram is shown. Only two spots are present.



The R_f values in this solvent and the M_r values for some amino acids, including all those that make up the tripeptide, are given in the table.

R *group on the amino acid*	R_f	M_r *of amino acid*
$-CH_3$	0.30	89
$-CH(CH_3)_2$	0.42	117
$-CH_2COOH$	0.60	133
$-CH_2CH_2COOH$	0.67	147

The constituent amino acids from 0.0100 mol of tripeptide are reacted separately with aqueous sodium hydroxide.

In total, 40.0 cm^3 of 1.00 mol dm^{-3} of aqueous sodium hydroxide is required to exactly neutralise the acid groups on the amino acids.

Which row identifies M_r of the tripeptide and the number of different tripeptides (as structural isomers) with this M_r that can be made from the amino acids present?

(A_r values: H = 1; C = 12; N = 14; O = 16)

	M_r of tripeptide	*number of different tripeptides possible*
A	275	3
B	311	3
C	319	3
D	345	3
E	275	6
F	311	6
G	319	6
H	345	6

39 An organic compound X shows the following characteristics:

- X contains only carbon, hydrogen and oxygen. It has only one functional group.
- 0.148 g of X reacts with a small excess of sodium, producing 24.0 cm^3 of hydrogen, measured at room temperature and pressure.
- 0.148 g of X is oxidised completely by 16.0 cm^3 of acidified 0.100 mol dm^{-3} potassium manganate(VII) solution.

The half-equation for the reduction of manganate(VII) ions is:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

Which statement about X is correct?

(A_r values: H = 1; C = 12; O = 16. Assume that one mole of gas occupies 24.0 dm^3 at room temperature and pressure.)

A X must be propanoic acid

B X must be methylpropan-1-ol

C X must be methylpropan-2-ol

D X must be butan-1-ol

E X must be butan-2-ol

F X could be either butan-1-ol or butan-2-ol

G X could be either butan-1-ol or methylpropan-1-ol

H X could be either butan-2-ol or methylpropan-2-ol

40 Lawn sand is used to remove moss and enhance the green colour of grass.

Lawn sand is a mixture of three compounds:

- silicon dioxide.
- an ionic salt, X. One mole of this salt contains 7 moles of water of crystallisation.
- a second ionic salt that provides the grass with nitrogen and is not hydrated.

Both salts contain one cation and one anion and are soluble in water. The anion in both salts is the same.

Excess water is stirred with 10.00 g of lawn sand, and the mixture then filtered. 8.12 g of dry silicon dioxide is obtained.

Excess acidified aqueous barium chloride is added to all of the filtrate. A white precipitate is formed. This mixture is filtered and all of this second filtrate is used in the next step.

Excess sodium hydroxide is now added to the filtrate. A green precipitate is formed.

When this mixture is heated, 480 cm^3 of ammonia, measured at room temperature and pressure, is produced.

Which of the following is an expression for the number of moles of X present in 10.00 g of lawn sand?

A_r values: H = 1; C = 12; N = 14; O = 16; Si = 28;
S = 32; Cl = 35.5; Br = 80; I = 127;
Mg = 24; Ca = 40; Fe = 56; Cu = 63.5; Ba = 137

(Assume that one mole of a gas occupies 24.0 dm^3 at room temperature and pressure.)

A $\frac{0.28}{76}$ mol

B $\frac{0.28}{139}$ mol

C $\frac{0.28}{167}$ mol

D $\frac{0.28}{200}$ mol

E $\frac{0.28}{244}$ mol

F $\frac{0.28}{263}$ mol

G $\frac{0.28}{278}$ mol

H $\frac{0.28}{306}$ mol

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