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Diploma Programme
Programme du diplôme
Programa del Diploma

# Chemistry
# Standard level
# Paper 1

Wednesday 10 November 2021 (afternoon)

45 minutes

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**Instructions to candidates**

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[30 marks]**.

8821 – 6104

13 pages

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# The Periodic Table

Atomic number

**Element**

Relative atomic mass

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1<br>**H**<br>1.01 | | | | | | | | | | | | | | | | | 2<br>**He**<br>4.00 |
| 2 | 3<br>**Li**<br>6.94 | 4<br>**Be**<br>9.01 | | | | | | | | | | | 5<br>**B**<br>10.81 | 6<br>**C**<br>12.01 | 7<br>**N**<br>14.01 | 8<br>**O**<br>16.00 | 9<br>**F**<br>19.00 | 10<br>**Ne**<br>20.18 |
| 3 | 11<br>**Na**<br>22.99 | 12<br>**Mg**<br>24.31 | | | | | | | | | | | 13<br>**Al**<br>26.98 | 14<br>**Si**<br>28.09 | 15<br>**P**<br>30.97 | 16<br>**S**<br>32.07 | 17<br>**Cl**<br>35.45 | 18<br>**Ar**<br>39.95 |
| 4 | 19<br>**K**<br>39.10 | 20<br>**Ca**<br>40.08 | 21<br>**Sc**<br>44.96 | 22<br>**Ti**<br>47.87 | 23<br>**V**<br>50.94 | 24<br>**Cr**<br>52.00 | 25<br>**Mn**<br>54.94 | 26<br>**Fe**<br>55.85 | 27<br>**Co**<br>58.93 | 28<br>**Ni**<br>58.69 | 29<br>**Cu**<br>63.55 | 30<br>**Zn**<br>65.38 | 31<br>**Ga**<br>69.72 | 32<br>**Ge**<br>72.63 | 33<br>**As**<br>74.92 | 34<br>**Se**<br>78.96 | 35<br>**Br**<br>79.90 | 36<br>**Kr**<br>83.90 |
| 5 | 37<br>**Rb**<br>85.47 | 38<br>**Sr**<br>87.62 | 39<br>**Y**<br>88.91 | 40<br>**Zr**<br>91.22 | 41<br>**Nb**<br>92.91 | 42<br>**Mo**<br>95.96 | 43<br>**Tc**<br>(98) | 44<br>**Ru**<br>101.07 | 45<br>**Rh**<br>102.91 | 46<br>**Pd**<br>106.42 | 47<br>**Ag**<br>107.87 | 48<br>**Cd**<br>112.41 | 49<br>**In**<br>114.82 | 50<br>**Sn**<br>118.71 | 51<br>**Sb**<br>121.76 | 52<br>**Te**<br>127.60 | 53<br>**I**<br>126.90 | 54<br>**Xe**<br>131.29 |
| 6 | 55<br>**Cs**<br>132.91 | 56<br>**Ba**<br>137.33 | 57 †<br>**La**<br>138.91 | 72<br>**Hf**<br>178.49 | 73<br>**Ta**<br>180.95 | 74<br>**W**<br>183.84 | 75<br>**Re**<br>186.21 | 76<br>**Os**<br>190.23 | 77<br>**Ir**<br>192.22 | 78<br>**Pt**<br>195.08 | 79<br>**Au**<br>196.97 | 80<br>**Hg**<br>200.59 | 81<br>**Tl**<br>204.38 | 82<br>**Pb**<br>207.2 | 83<br>**Bi**<br>208.98 | 84<br>**Po**<br>(209) | 85<br>**At**<br>(210) | 86<br>**Rn**<br>(222) |
| 7 | 87<br>**Fr**<br>(223) | 88<br>**Ra**<br>(226) | 89 ‡<br>**Ac**<br>(227) | 104<br>**Rf**<br>(267) | 105<br>**Db**<br>(268) | 106<br>**Sg**<br>(269) | 107<br>**Bh**<br>(270) | 108<br>**Hs**<br>(269) | 109<br>**Mt**<br>(278) | 110<br>**Ds**<br>(281) | 111<br>**Rg**<br>(281) | 112<br>**Cn**<br>(285) | 113<br>**Unt**<br>(286) | 114<br>**Uug**<br>(289) | 115<br>**Uup**<br>(288) | 116<br>**Uuh**<br>(293) | 117<br>**Uus**<br>(294) | 118<br>**Uuo**<br>(294) |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| † | 58<br>**Ce**<br>140.12 | 59<br>**Pr**<br>140.91 | 60<br>**Nd**<br>144.24 | 61<br>**Pm**<br>(145) | 62<br>**Sm**<br>150.36 | 63<br>**Eu**<br>151.96 | 64<br>**Gd**<br>157.25 | 65<br>**Tb**<br>158.93 | 66<br>**Dy**<br>162.50 | 67<br>**Ho**<br>164.93 | 68<br>**Er**<br>167.26 | 69<br>**Tm**<br>168.93 | 70<br>**Yb**<br>173.05 | 71<br>**Lu**<br>174.97 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ‡ | 90<br>**Th**<br>232.04 | 91<br>**Pa**<br>231.04 | 92<br>**U**<br>238.03 | 93<br>**Np**<br>(237) | 94<br>**Pu**<br>(244) | 95<br>**Am**<br>(243) | 96<br>**Cm**<br>(247) | 97<br>**Bk**<br>(247) | 98<br>**Cf**<br>(251) | 99<br>**Es**<br>(252) | 100<br>**Fm**<br>(257) | 101<br>**Md**<br>(258) | 102<br>**No**<br>(259) | 103<br>**Lr**<br>(262) |



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**1.** What is the number of hydrogen atoms in 2.00 moles of $Ca(HCO_3)_2$?

Avogadro's constant, $L$ or $N_A$: $6.02 \times 10^{23}\ mol^{-1}$

A. 2.00

B. 4.00

C. $1.20 \times 10^{24}$

D. $2.41 \times 10^{24}$

**2.** Which statement describes all homogeneous mixtures?

A. Any sample has the same ratio of the components.

B. The components are covalently bonded together.

C. The components cannot be easily separated.

D. The mixture needs a specific ratio of components to form.

**3.** Which combination is correct?

| | Structural formula | Empirical formula | IHD |
|---|---|---|---|
| A. | $C_6H_{12}$ | $C_2H_4$ | 1 |
| B. | $C_6H_{14}$ | $C_3H_7$ | 0 |
| C. | $C_8H_8$ | CH | 3 |
| D. | $C_8H_{10}$ | $C_4H_6$ | 4 |



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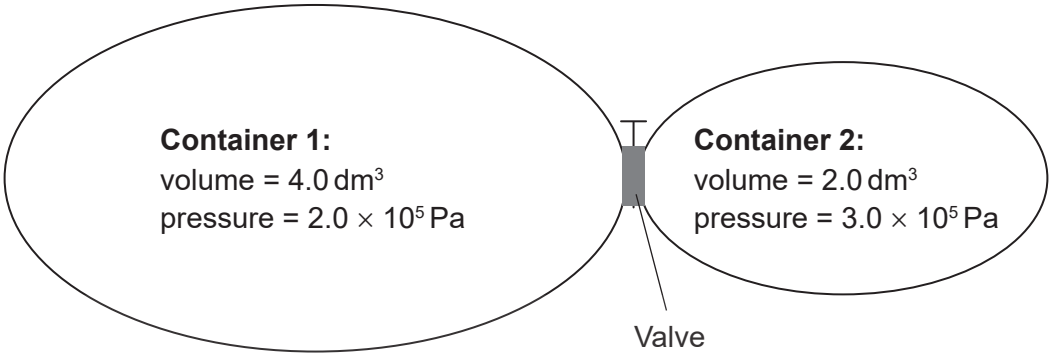
**4.** The two containers shown are connected by a valve. What is the total pressure after the valve is opened and the two gas samples are allowed to mix at constant temperature?



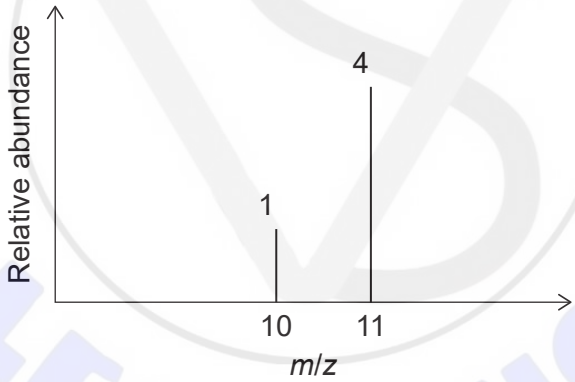

A. $1.5 \times 10^5$ Pa

B. $2.3 \times 10^5$ Pa

C. $2.5 \times 10^5$ Pa

D. $5.0 \times 10^5$ Pa

**5.** Consider the mass spectrum of an element:




What is the relative atomic mass of this element?

A. 10.2

B. 10.5

C. 10.8

D. 10.9

**6.** How many p-orbitals are occupied in a phosphorus atom?

A. 2

B. 3

C. 5

D. 6

**7.** Which element has the highest metallic character in Group 14?

A. C

B. Si

C. Ge

D. Sn

**8.** Which combination describes the acid–base nature of aluminium and phosphorus oxides?

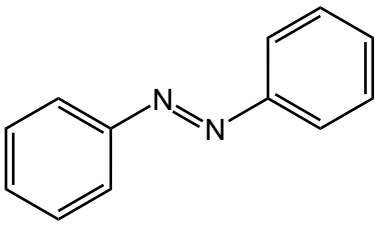
| | **Aluminium** | **Phosphorus** |
|---|---|---|
| A. | Amphoteric oxide | Acidic oxide |
| B. | Basic oxide | Amphoteric oxide |
| C. | Acidic oxide | Amphoteric oxide |
| D. | Amphoteric oxide | Basic oxide |

**9.** Which molecule has the **weakest** nitrogen to nitrogen bond?

A. $N_2$

B. $N_2H_2$

C. $N_2H_4$

D. 

**10.** Which combination would create the strongest ionic bond?

| | Ionic radius | Charges on ions |
|---|---|---|
| A. | large | high |
| B. | large | low |
| C. | small | high |
| D. | small | low |

**11.** Which compound contains both ionic and covalent bonds?

A. $CH_3COONa$

B. $CH_3COOH$

C. $K_2O$

D. $CaCl_2$

**12.** The following compounds have similar relative molecular masses. What is the order of increasing boiling point?

A. $CH_3CH_2CH_2OH < CH_3CH_2CHO < CH_3COOH$

B. $CH_3CH_2CHO < CH_3CH_2CH_2OH < CH_3COOH$

C. $CH_3CH_2CHO < CH_3COOH < CH_3CH_2CH_2OH$

D. $CH_3COOH < CH_3CH_2CHO < CH_3CH_2CH_2OH$

**13.** Which alcohol is **least** soluble in water?

A. $CH_3OH$

B. $CH_3CH_2OH$

C. $CH_3CH_2CH_2OH$

D. $CH_3CH_2CH_2CH_2OH$

**14.** Which combustion reaction releases the **least** energy per mole of $C_3H_8$?

| | Approximate bond enthalpy / $kJ\,mol^{-1}$ |
|---|---|
| O=O | 500 |
| C=O | 800 |
| C≡O | 1000 |

A. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

B. $C_3H_8(g) + \frac{9}{2}O_2(g) \rightarrow 2CO_2(g) + CO(g) + 4H_2O(g)$

C. $C_3H_8(g) + 4O_2(g) \rightarrow CO_2(g) + 2CO(g) + 4H_2O(g)$

D. $C_3H_8(g) + \frac{7}{2}O_2(g) \rightarrow 3CO(g) + 4H_2O(g)$

**15.** Which equation represents the standard enthalpy of formation of lithium oxide?

A. $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$

B. $2Li(s) + \frac{1}{2}O_2(g) \rightarrow Li_2O(s)$

C. $Li(s) + \frac{1}{4}O_2(g) \rightarrow \frac{1}{2}Li_2O(s)$

D. $Li(g) + \frac{1}{4}O_2(g) \rightarrow \frac{1}{2}Li_2O(g)$

**16.** Which statement describes an endothermic reaction?

A. The bonds broken are stronger than the bonds formed.

B. The enthalpy of the reactants is higher than the enthalpy of the products.

C. The temperature of the surroundings increases.

D. The products are more stable than the reactants.

**17.** Which instrument would best monitor the rate of this reaction?

$$2KI(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + I_2(aq)$$

A. Balance

B. Colorimeter

C. Volumetric flask

D. Gas syringe

**18.** Which combination has the greatest rate of reaction at room temperature?

| | **Zinc** | **$CuSO_4$ (aq)** |
|---|---|---|
| A. | 1.00 g Zn powder | 50.0 $cm^3$ of 0.200 mol $dm^{-3}$ $CuSO_4$ (aq) |
| B. | 1.00 g Zn powder | 100.0 $cm^3$ of 0.100 mol $dm^{-3}$ $CuSO_4$ (aq) |
| C. | 1.00 g Zn strip | 50.0 $cm^3$ of 0.200 mol $dm^{-3}$ $CuSO_4$ (aq) |
| D. | 1.00 g Zn strip | 100.0 $cm^3$ of 0.100 mol $dm^{-3}$ $CuSO_4$ (aq) |

**19.** The equilibrium $2H_2(g) + N_2(g) \rightleftharpoons N_2H_4(g)$ has an equilibrium constant, *K,* at 150 °C.

What is the equilibrium constant at 150 °C, for the reverse reaction?

$$N_2H_4(g) \rightleftharpoons 2H_2(g) + N_2(g)$$

A. $K$

B. $K^{-1}$

C. $-K$

D. $2K$

**20.** Which ions are present in an aqueous solution of $Na_2CO_3$?

I. $HCO_3^-$

II. $OH^-$

III. $CO_3^{2-}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**21.** What is the conjugate acid of $HS^-$?

A. $H_2S$

B. $S^{2-}$

C. $H_2SO_3$

D. $H_2SO_4$

**22.** What is the change in the oxidation state of oxygen?

$$2Fe^{2+}(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow 2H_2O(l) + 2Fe^{3+}(aq)$$

A. +1

B. 0

C. –1

D. –2

**23.** Which statement is correct about the electrolysis of molten lead(II) bromide, $PbBr_2$?

A. $Br^-$ ions accept electrons at the cathode (negative electrode).

B. $Pb^{2+}$ ions accept electrons at the anode (positive electrode).

C. $Br^-$ ions lose electrons at the anode (positive electrode).

D. $Pb^{2+}$ ions lose electrons at the cathode (negative electrode).



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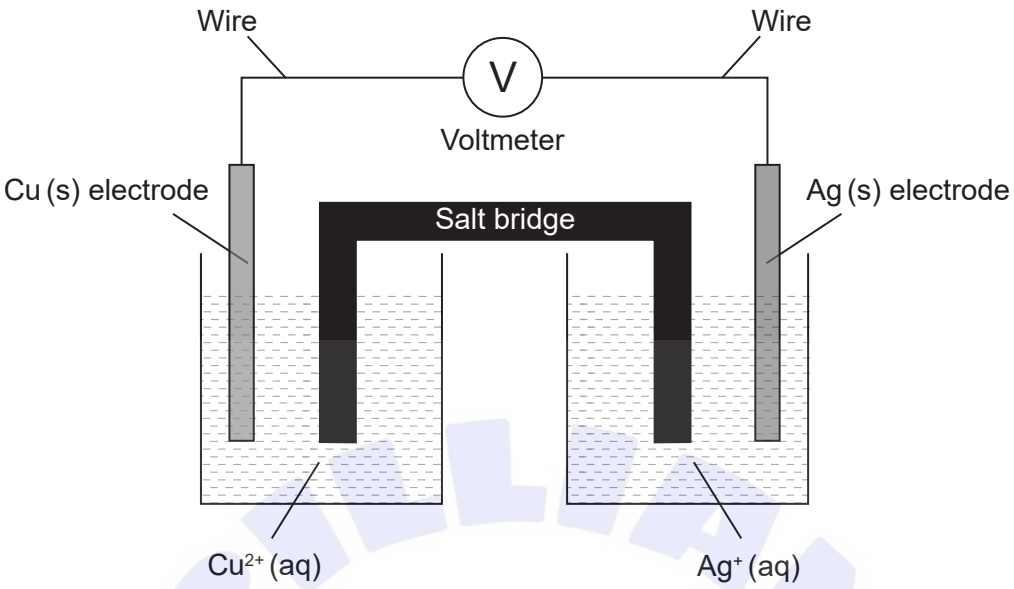
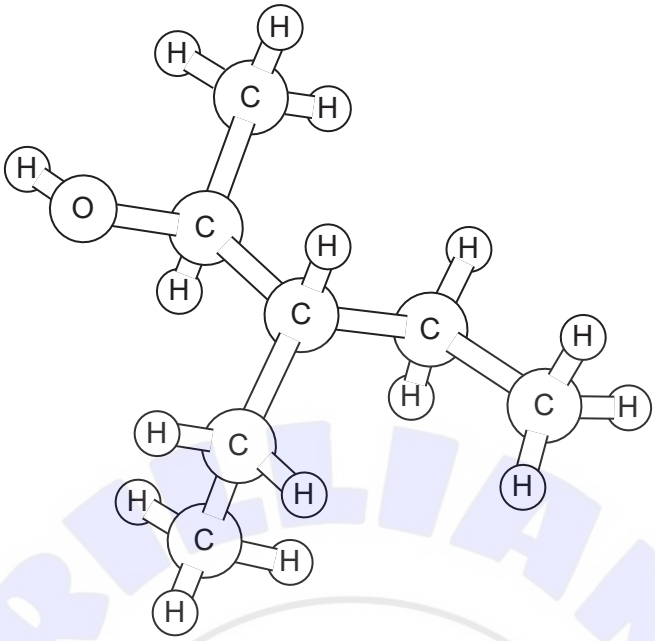
**24.** Consider this voltaic cell, where Cu is a more reactive metal than Ag:




Which combination describes the movement of charge in this cell?

| | Flow of electrons in wire | Flow of negative ions in salt bridge |
|---|---|---|
| A. | Ag (s) to Cu (s) | Toward $Ag^{+}$ (aq) |
| B. | Cu (s) to Ag (s) | Toward $Ag^{+}$ (aq) |
| C. | Ag (s) to Cu (s) | Toward $Cu^{2+}$ (aq) |
| D. | Cu (s) to Ag (s) | Toward $Cu^{2+}$ (aq) |

**25.** What is the name of this substance using IUPAC rules?




A. 2-ethyl-1-methylbutan-1-ol

B. 1-methyl-2-ethylbutan-1-ol

C. 3-ethylpentan-2-ol

D. 3-ethylpentan-4-ol

**26.** Which pair of compounds are structural isomers?

A. Propane and propene

B. Propanal and propanone

C. Propan-1-ol and propanal

D. Propyl propanoate and propanoic acid

**27.** What is the general formula of alkynes?

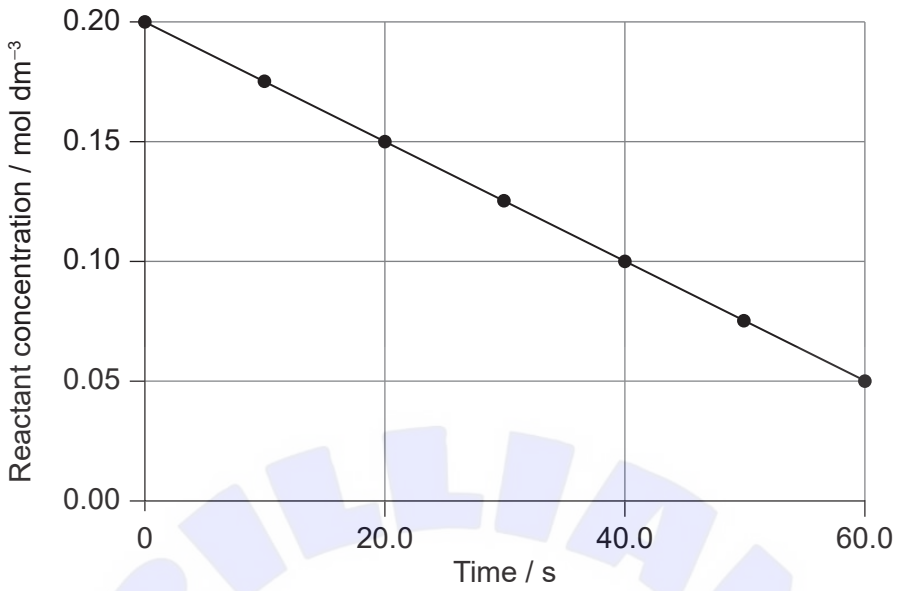
A. $C_nH_{2n+2}$

B. $C_nH_{2n}$

C. $C_nH_{2n-2}$

D. $C_nH_n$

**28.** What is the slope of the graph?




A. $-0.0025\,\text{mol dm}^{-3}\,\text{s}^{-1}$

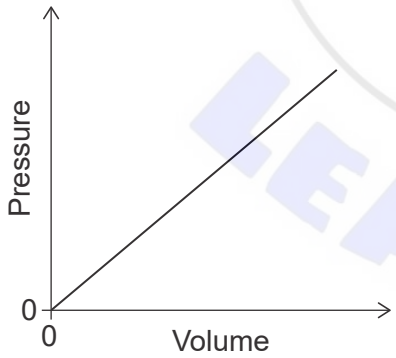
B. $-0.0025\,\text{mol dm}^{-3}\,\text{s}$

C. $-0.0033\,\text{mol dm}^{-3}\,\text{s}^{-1}$

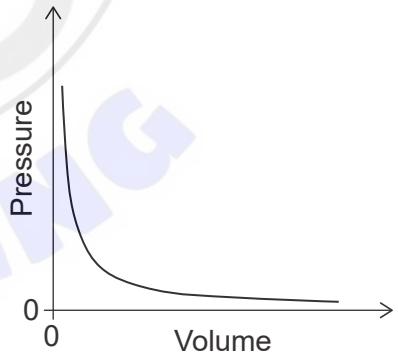
D. $-0.0033\,\text{mol dm}^{-3}\,\text{s}$

**29.** Which graph shows the relationship between the pressure and volume of a sample of gas at constant temperature?

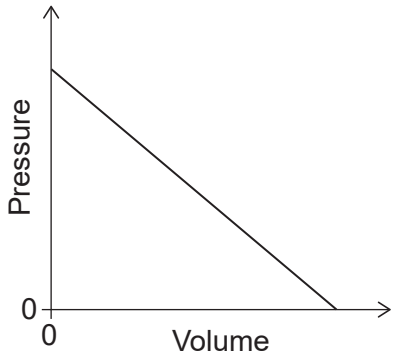
A.



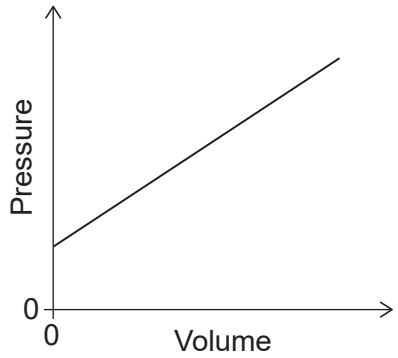

B.



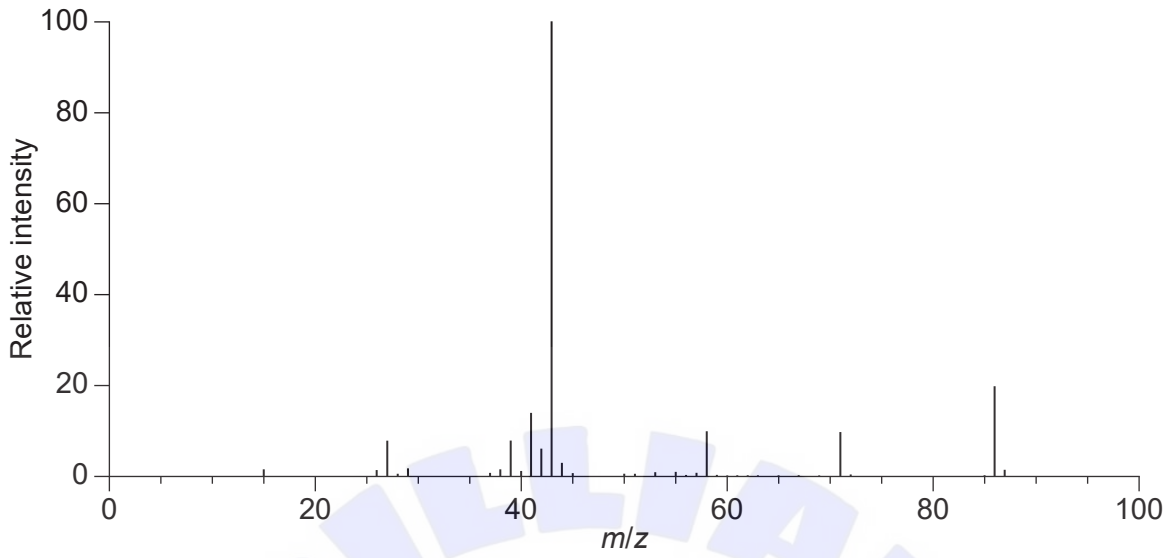

C.




D.



**30.** What can be deduced from the mass spectrum of $CH_3COCH_2CH_2CH_3$?




A. The molar mass is $43\,g\,mol^{-1}$.

B. The atoms have many isotopes.

C. The most likely bond to break is C–C between carbons 2 and 3.

D. The signal with the largest mass is due to the oxidation of the ketone in the spectrometer.

**References:**


**14.** Chemistry: Atoms First 2e, https://openstax.org/books/chemistry-atoms-first-2e/pages/9-4-strengths-of-ionic-and-covalent-bonds © 1999–2021, Rice University. Except where otherwise noted, textbooks on this site are licensed under a Creative Commons Attribution 4.0 International License. (CC BY 4.0) https://creativecommons.org/licenses/by/4.0/.

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