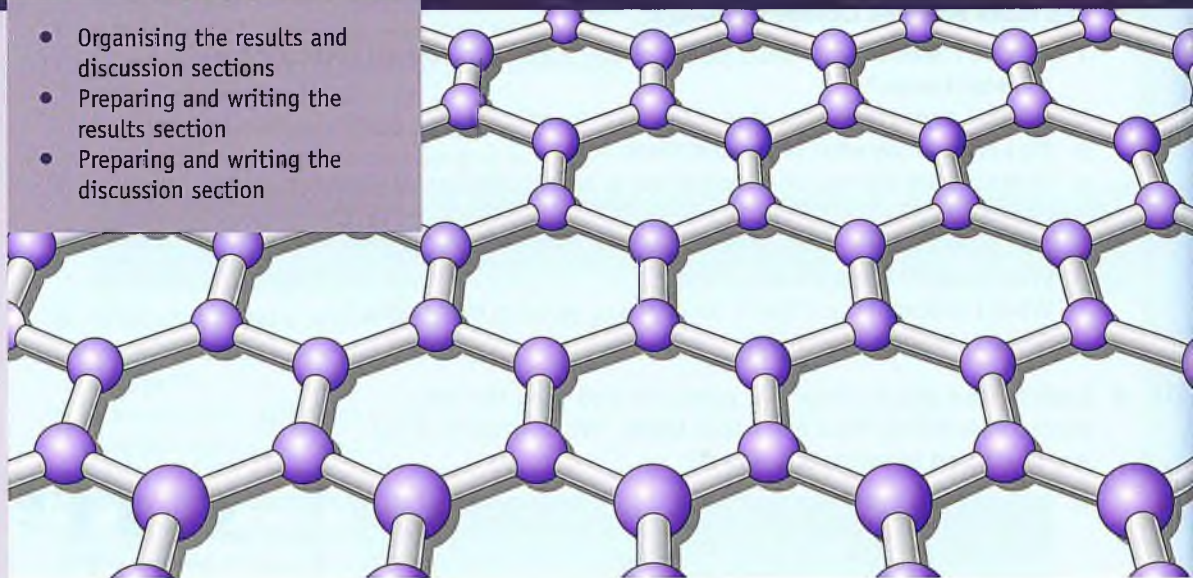


UNIT 8

Writing up research 3: results and discussion

- Organising the results and discussion sections
- Preparing and writing the results section
- Preparing and writing the discussion section



Organising the results and discussion sections

1 a In pairs, discuss the following questions.

- 1 How is the information in the results section of a paper different from the discussion section?
- 2 Why do researchers usually keep the results and discussion sections separate?
- 3 Why might some researchers present the results and discussion together as one section?
- 4 Some papers include a conclusion section. What is the difference between a discussion and a conclusion?

b Read three extracts from a research paper, ignoring the highlighted words and phrases. Then match an extract (A–C) with the part of the paper it comes from: the materials and methods section, the results section or the discussion section.

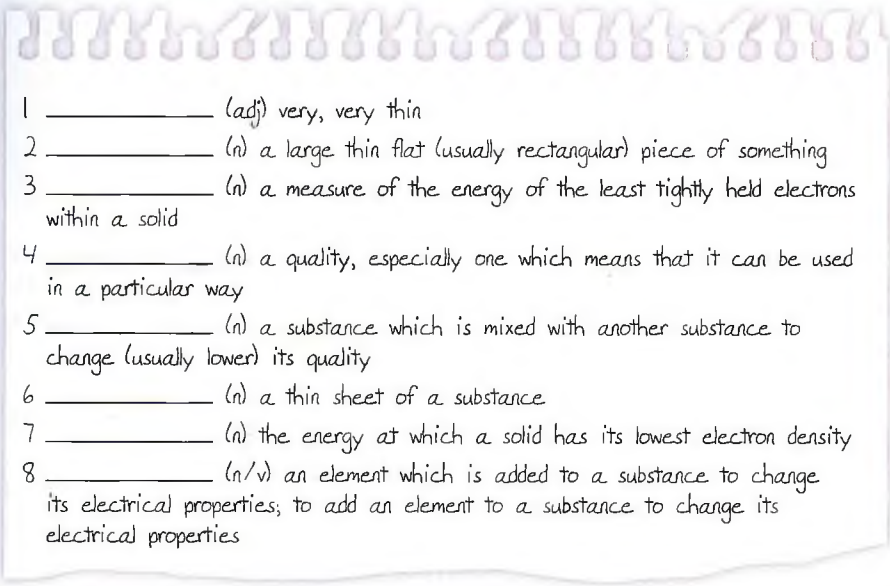
- A The majority of the activated carbons **examined** have surface areas **ranging between 900 and 2000 m²/g**, and the ratio of micropore volume to total pore volume ranges between 0.26 and 0.65.
- B **The highest** storage factor **attained** is 89 for compacted grain-based activated carbons from rain sorghum. **Therefore**, sorghum-based activated carbons **will be** effective for natural gas storage in the fuel tanks of motor vehicles.
- C **Carbonisation and activation were performed** in an electrical-resistance furnace under a steady flow of gaseous N₂. The samples **were contained** in cylindrical baskets made from 60 mesh stainless steel gauze.

C Read the extracts again. Which of the highlighted words or phrases:

- a describe(s) changes to the materials?
- b describe(s) the experimental process?
- c introduce(s) a significant result?
- d introduce(s) the highest and lowest values that were looked at?
- e introduce(s) the researcher's conclusion?
- f make(s) a confident prediction?
- g mean(s) the same as 'looked at'?
- h mean(s) the same as 'reached successfully'?

- 2 a** Max, a chemistry PhD student, is investigating the development of carbon-based electronics. His research focuses on the possible use of graphene in electronics. Before writing his paper, Max is reviewing some words related to his research. Complete the definitions (1–8) using the words in the box from Max's list. Then in pairs, try to guess what Max has been investigating.

Dirac point dope/dopant Fermi level impurity layer property of sth sheet
ultra-thin

- 
- 1 _____ (adj) very, very thin
 - 2 _____ (n) a large thin flat (usually rectangular) piece of something
 - 3 _____ (n) a measure of the energy of the least tightly held electrons within a solid
 - 4 _____ (n) a quality, especially one which means that it can be used in a particular way
 - 5 _____ (n) a substance which is mixed with another substance to change (usually lower) its quality
 - 6 _____ (n) a thin sheet of a substance
 - 7 _____ (n) the energy at which a solid has its lowest electron density
 - 8 _____ (n/v) an element which is added to a substance to change its electrical properties; to add an element to a substance to change its electrical properties

- b ► 8.1** Max is discussing his research with Florence, a new post-doctoral fellow in the lab. Listen and choose the correct word to complete the sentences.

- 1 Graphene is an ultra-thin layer of **boron** / **carbon**.
- 2 Max **adds the dopant to the structure of** / **lays the dopant onto** the graphene.
- 3 Max is currently using **nitrogen dioxide** / **F4-TCNQ** as the dopant.
- 4 Max hopes that the dopant he is currently using can reduce the **positive** / **negative** charge from the graphene layer.
- 5 Max also wants to know if the current dopant reacts to **air** / **water** and heat.

- 3 a Read the following extract from the draft of Max's results. Which of a–c below best summarises the main idea of Max's paragraph? Why are the other two options *not* suitable here?

- a Charge neutrality reached at 0.8 nm F4-TCNQ
- b Effect of F4-TCNQ on monolayer graphene
- c Fermi level in graphene above Dirac point

- b Read the extract again more carefully and make the following corrections.

- 1 Two of the sentences do not belong in the results section. Which ones are they? Where should they be in the paper?
- 2 Find and correct three verbs in the wrong tense. Why are they wrong?

- c In pairs, answer the following questions about the corrected paragraph in Exercise 3a.

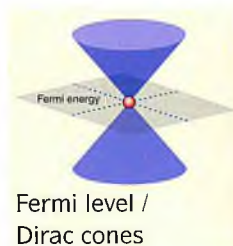
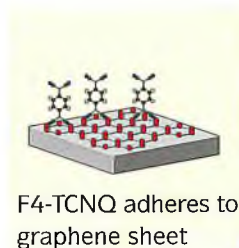
- 1 The purpose of the first sentence is to:
 - a give the reader information about the structure of graphene
 - b describe a key result of the experiment
 - c tell the reader which table or figure has the evidence for the key result
- 2 What is the purpose of the other sentences in the paragraph?

- d Read the following sentences from the results section of Max's paper. They are not in order. Then decide which two sentences describe a key result in his experiment.

- a A comparison with the nonfluorinated version of the F4-TCNQ molecule, TCNQ, shows that the charge transfer increases significantly when the F4 is present.
- b As the temperature increased above 75 °C, the difference between the Dirac energy and the Fermi energy also increased.
- c Charge transfer occurs with TCNQ, but the Fermi energy always remains at least 0.25 eV above the Dirac point (Fig. 4a).
- d The difference returned to the level of a graphene layer at 230 °C.
- e The F4-TCNQ layer is sensitive to temperature.
- f The maximum shift of the band structure is obtained for a TCNQ deposition of 0.4 nm (Fig. 4d), but no additional shift is observed for higher amounts of deposited molecules.

A paragraph contains a topic sentence and one or more supporting sentences. The topic sentence contains the main idea for the paragraph. In the results section, the topic sentence of each paragraph should describe a key result and the supporting sentences should provide a summary of the relevant findings leading to the main result. The topic sentence is usually the first sentence in the paragraph.

- e Look at sentences a–f in Exercise 3d again. The two sentences which described a key result are topic sentences. First, find two supporting sentences for each topic sentence. Then put all the sentences in order to make two paragraphs.



Doping with F4-TCNQ has an effect on the charge of the graphene layer. The doping level of the graphene layers was precisely monitored with ARPES measurements. For a pure monolayer of graphene, the Fermi level is located about 0.42 eV above the Dirac point (Fig. 1a). As increasing amounts of F4-TCNQ were deposited, the Fermi level moved towards the Dirac point (Figs. 1b–1d). Evidently, deposition of F4-TCNQ activated electron transfer from graphene toward the molecule thus neutralising the excess negative charge. When a 0.8 nm-thick layer of molecules is deposited, charge neutrality was reached. For a thickness of the molecular film above 0.8 nm, no additional shift of the Fermi energy is observed (Fig. 1e).

Think about an experiment you have been working on or that you are familiar with. What are the most significant results and the main ideas you want to discuss? Write topic sentences (only) for the results and the discussion sections of a paper and put them into a logical order.

Preparing and writing the results section

- 5 a ▶ 8.2 Florence is advising Max on writing up the results section of his paper. Listen and complete Max's notes with 1–3 words you hear in the conversation.

- b Which part of Florence's advice do you think is most useful? Which is least useful for you? Why?



- only results - no interpretation or methodology
- highlight both my key and (1) _____ findings
- the text to follow same order as the (2) _____
- make each paragraph relate to one of my (3) _____
- include (4) _____ to my visuals in the text
- be concise (don't use (5) _____)
- use active voice and write in past tense
- can use (6) _____ to make the text clearer

- c Max uses the order of his visual data to organise the text of his results section. Put the words in brackets in the correct order to complete the extracts from his results (1–4).

- 1 (shown / as / Fig. 1a / in), for a pure monolayer of graphene, the Fermi level is located about 0.42 eV above the Dirac point.
- 2 (shows / as / Fig. 1d), when a 0.8 nm-thick layer of molecules was deposited, charge neutrality was reached.
- 3 (be / in / Fig. 3d / observed / it / that / can) as the temperature increased above 75 °C, the difference between the Dirac energy and the Fermi energy also increased.
- 4 (that / Fig. 3d / shows) the difference returned to the level of a pure graphene layer at 230 °C.

- 6 a Max wants to compare and contrast the doping effects of TCNQ and F4-TCNQ. Read the following draft paragraph and underline the phrases he uses to describe a comparison or a contrast.

In contrast to F4-TCNQ, the nonfluorinated version, TCNQ, showed a far less effective charge transfer, even though the fluorine atoms are not directly involved in the charge-transfer process. In the case of TCNQ, the electron affinity was 2.8 eV compared to 5.24 eV for F4-TCNQ. While charge neutrality was reached for F4-TCNQ, with TCNQ the Fermi energy remained at least 0.25 eV above the Dirac point, as shown in Fig. 4. The maximum shift of the band structure was obtained for a TCNQ coverage of 0.4 nm (see Fig. 4d), half that of F4-TCNQ, and no additional shift was observed for higher amounts of deposited molecules.

- b** The phrases in bold describe the results of a number of other experiments. Match the beginnings (1–8) to the endings (a–h) to complete extracts from eight different research papers.

1 At high temperature and high pressure, olivine showed a noticeable	a differences were seen between the activation efficiency of NaOH and KOH.
2 The carbon nanotubes had an extremely	b differences in the pH and temperature over the 3-month period.
3 For the hydroxide-to-fibre ratio of 4:1, slight	c effect on DNA synthesis and did not interact with the EGF receptor.
4 TAGH had only a minor	d high capacity.
5 The anxiety-related metabolic differences observed in urine were significantly	e reduced following 1 and 2 weeks of dark chocolate consumption.
6 There were only marginal	f slower than <i>C. draconoides</i> .
7 The robot demonstrated looping behaviour that was similar to that of the real moth and was also highly	g drop in strength.
8 When running horizontally on the high-friction surface <i>T. mauritanica</i> 's average speed was considerably	h successful at locating the odour source.

- c** Look at the phrases in bold in Exercise 6b and find adjectives and adverbs which express:

- a a large degree
b a small degree

- d** Complete the paragraphs from the results section of a paper using the words and phrases in the box.

as can be seen in considerably contrast to noticeably thicker resulted in a longer while

During the rapid heating, the Ni near the Ni/SiC interface reacted with the SiC, which resulted in carbon atoms moving into the Ni. The carbon atoms then separated onto the surface of the Ni during the cooling procedure, forming graphene layers (1) _____. Fig. 1b. In (2) _____ the graphene generated using single-crystalline SiC, the graphene synthesised by this process is (3) _____ easier to remove from the SiC surface.

A slower heating rate (4) _____ process. As shown in Fig. 4, more carbon atoms were released into the Ni in a long process. Higher carbon concentration in the Ni produced a (5) _____ carbon nanofilm on the Ni surface, (6) _____ a lower carbon concentration reduced the thickness of the carbon nanofilm and formed graphene.

7

Think about an experiment you have been working on or that you are familiar with. Use the topic sentences you wrote for Exercise 4 to write at least one paragraph for the results section of a paper.

Preparing and writing the discussion section

- 8 a Max is asking Florence for advice on writing up the discussion section of his paper. Look at some of the questions Max asks Florence. Can you answer any of them?
- 1 Should I work through my discussion in the same order I used for the results?
 - 2 Can I mention any new results?
 - 3 Do I need to mention the results again?
 - 4 Can I refer to other work that's been done in the area?
 - 5 In terms of language, is there anything in particular I should be careful with?

- b ► 8.3 Listen to the conversation and make notes on the answers Florence gives to Max's questions.

- 9 a Florence advises Max to use noun phrases. Noun phrases can be used to summarise a lot of information efficiently. Read a paragraph from an early draft of Max's paper. Then complete the sentence from a later draft using the words and phrases in the box.

deposition of electron transfer from movement of towards

The Fermi level moves towards the Dirac point. When this happens, it indicates that F4-TCNQ has been deposited. When the F4-TCNQ has been deposited, the electrons are activated. When the electrons are activated, they are transferred from graphene towards the molecule.

The (1) _____ the Fermi level (2) _____ the Dirac point indicates that (3) _____ F4-TCNQ activates (4) _____ (5) _____ graphene towards the molecule.

- b Complete the following sentences from three more research papers. In each space, write the noun form of the word in brackets or use *of*, *on* or *to*.

- 1 The _____ (able) _____ a gecko _____ walk _____ walls demonstrates that _____ (activate) _____ the adhesive system improves the gecko's movement over smooth surfaces.
- 2 The _____ (form) _____ a CaP layer _____ the surface allowed further crystal growth.
- 3 Although the species *M. fortunata* has a lower _____ (expose) to vent fluids it seems to have a higher _____ (accumulate) _____ metals in its tissues.



- c Florence also advises Max to be concise. In pairs, read another extract from Max's paper on the right. Then combine the second and third sentences of the extract into one sentence in two different ways using:

- a relative pronoun (*which*, *that*, *who*, etc.)
- a VERB-*ing*

The F4-TCNQ layer is stable in air, but appears to be temperature sensitive. At temperatures above 75 °C the energy difference increases. This increase indicates that molecular desorption occurs.

d Rewrite the following extracts from three different papers using either a relative pronoun (*which, that, who, etc.*) or a *VERB-ing*.

- 1 The adhesive apparatus is only activated on sloped surfaces, not on flat surfaces even when slippage occurs. This results in greatly reduced sprinting velocity on smooth, flat surfaces.
- 2 Consumption of dark chocolate resulted in the decrease in the stress hormone cortisol in the urine. This suggests potential benefits of dark chocolate consumption.
- 3 On exposure to metals, *B. azoricus* demonstrates considerable antioxidant enzymatic activity. This reflects a physiological adaptation to continuous metal exposure.

10 Look at the paragraph(s) for the results section you wrote in Exercise 7. Write a paragraph for a discussion section for those results.

11 a The discussion section of a paper often describes limitations of the current research and what experiments could be done in future. Read the following statements about Max's research and decide whether they describe a limitation (L) or an idea for future research (F).

- 1 ☐ The process of charge transfer has not been investigated. _____
- 2 ☐ Desorption might occur because of the temperature used or because of the vacuum. _____
- 3 ☐ Try using higher temperatures at atmospheric pressure to see what happens. _____
- 4 ☐ Try doping with other TCNQ-related molecules. _____
- 5 ☐ The graphene sample thickness is not consistent. _____
- 6 ☐ F4-TCNQ might be useful in silicon-based as well as graphene-based electronics. _____
- 7 ☐ Investigate different ways of applying the F4-TCNQ layer. _____

b ▶ **8.4** Listen to Max and his supervisor, Dan, discussing the latest draft of Max's paper. Tick the points from Exercise 11a they discuss.

12 a Based on Dan's suggestion, Max has written a paragraph for his paper on limitations and future research. Look at the underlined phrases. Which ones express limitations of the research and which suggest future research?

The results presented here indicate that F4-TCNQ has potential as a doping agent for graphene-based electronics, but further studies are needed. The findings suggest that an increase in the temperature above 75 °C causes molecular desorption from the graphene surface. However, the process was carried out in a vacuum, which could be causing the desorption. The results of the present study might have been different if the process had been carried out at atmospheric pressure and it would be beneficial to investigate this further. Another limitation of the study is the inconsistent thickness of the graphene samples. Future research should also be encouraged to examine alternative methods of applying the F4-TCNQ layer. This has the potential to increase the commercial use of this doping method.

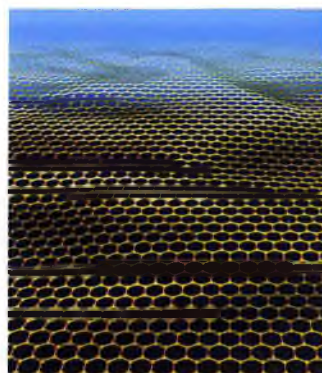
b Look at the phrases below. Which can be used to express limitations and which suggestions for future research?

- 1 The scope of this study did not permit us to examine ...
- 2 Given this limitation, we do not know if/whether ...
- 3 It is hoped that this research can serve as a basis for future studies into ...
- 4 This is a clear limitation of the study and raises further questions related to ...
- 5 These results are preliminary findings and suggest that further research on ...

c The paragraph below describes the limitations and suggestions for future direction of a study looking at the production of graphene layers. Complete the paragraph using the words and phrases in the box.

clear given hoped indicates permit raises scope serve as

The study (1) _____ that it is possible to produce large-area graphene films using a solid-phase-based method. It is (2) _____ that this research can (3) _____ a basis for further studies into graphene synthesis. One limitation of the present research is that the (4) _____ of the study did not (5) _____ us to investigate the differences between using 6H-SiC and 3C-SiC/Si substrates. (6) _____ this limitation, we do not know if this method is selective for the type of SiC substrate. In addition, the current study did not investigate a range of heating rates. It is possible that lower temperatures could be used if the process were lengthened. This is a (7) _____ limitation of the study and (8) _____ further research questions related to the possibility of optimising processing conditions to better control graphene production.



The structure of graphene



Graphene sheet

13 a Look at Max's concluding paragraph. Which sentences (1–6) explain:

- a the problem?
- b how other researchers approached the problem and what they found?
- c the key findings of the current research?

(1) Freshly grown graphene displays an excess negative charge. (2) As presented in several other studies, approaches used to remove this charge have all displayed practical disadvantages (Riedl *et al.*, 2009; Lohmann, von Klitzing and Smet, 2009). (3) However, in a previous paper, it was shown that surface-transfer doping was a simple and reliable way to dope graphene (Chen *et al.*, 2009). (4) Recent work has suggested theoretically that F4-TCNQ could have a doping effect on graphene (Pinto *et al.*, 2009). (5) The present study has demonstrated the effect experimentally and shown that the excess negative charge in monolayer graphene can be fully compensated by functionalising its surface with F4-TCNQ. (6) In addition, we have demonstrated that the molecular layer is stable when exposed to air, preserved up to 75 °C and is totally reversible at higher temperatures.

b Underline the language used to refer to other researchers' work.

14 Write a concluding paragraph for the discussion section of the subject you wrote about for Exercises 7 and 10. Include the limitations and future direction of the research.