High Pressure Science: Why diamonds are a (scientist) girl's best friend!

Pupil Name

Handbook Designed by Dr Jone Zabaleta

Timetable and Assignment Submission

Timetable – Tutorials

1			
2			
3			
4			
5			
6 (Feedback)			

Timetable – Homework Assignments

Tutorial 1		
Tutorial 2		
Tutorial 3		
Tutorial 4		
Tutorial 5		

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on 9th August	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

The Brilliant Club KS4 Programme – Pupil Feedback Report

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at A-level
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Name of PhD Tutor			
Title of Assignment			
Name of Pupil			
Name of School			
ORIGINAL MARK / 100		FINAL MARK / 100	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the PhD tutor should give an explanation in this section:

Learning Feedback Comment 1 –	
What you did in relation to this Key Learning Priority	How you could improve in the future

Learning Feedback Comment 2 –	
What you did in relation to this Key Learning Priority	How you could improve in the future
Learning Feedback Comment 3 –	
What you did in relation to this Key Learning Priority	How you could improve in the future
Resilience Comment	
How you showed learning resilience during the course	How you could build learning resilience in the future

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Course Rationale

An adult elephant standing on a toy car would surely produce a dramatic change in the toy, although one that the little car owner would not gladly witness. . .

Pressure is a powerful tool to change the structure and properties of matter. We have all experienced what pressure feels like by swimming a few meters under water. The 1 bar sea-level atmospheric pressure increases by 1 bar every 10 meters that we go below the water surface. Deeper into the Earth's crust pressure increases rapidly to magnitudes that are beyond human experience. We then enter the gigapascal (GPa) regime, which is to say 10,000 times the atmospheric pressure range. Materials behave then in a very different way to how they do in our everyday life. Helium gas becomes solid roughly above 10 GPa and oxygen gas becomes metallic at 100 GPa. Some materials show changes in their colours, others can become superconducting. A whole new range of materials' properties can be discovered and explored by squeezing them hard enough. But, how do we get an elephant in our labs? Diamonds do the trick for us. By compressing a material placed in a protected cavity between two diamonds we can reach the GPa range and study new behaviours and exciting physical phenomena.

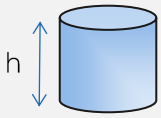
The students in this course will learn about High Pressure and will develop awareness of the many and different materials that make up our physical reality. The microscopic structure of those materials defines the physical properties they manifest, whether electrical, optical or mechanical, to name a few, and they also define their applications. Students will learn how these properties can be modified using High Pressure. By the end of the course students will be able to produce a scientific research paper describing a pressure experiment and its results.

Mark Scheme Table

	Skills	1st (70-100)	2:1 (60-69)	2:2 (50-59)
Subject knowledge	Knowledge and Understanding	o All content included is relevant to the general topic and to the specific question/title o Good understanding of all the relevant topics. o Scientific terms are defined and used accurately throughout o Clear justification on how the content included is related to the specific issues that are the focus of the assignment	o Most of the content included is relevant to the general topic and to the specific question/title o Good understanding of most the relevant topics o Scientific terms are used accurately but not always clearly defined. o Adequate justification on how the content included is related to the specific issues that are the focus of the assignment	o Some of the content included is relevant to the general topic and to the specific question/title o Good understanding on some of the relevant topics but occasional confusion on others. o Scientific terms are used mostly accurately with occasional confusion and often not defined. o Some justification on how the content included is related to the specific issues that are the focus of the assignment o
Critical thinking	Research and Evidence	o Inclusion of rich sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas o Use evidence/calculations to support claims/assertions/ideas, consistently clearly and convincingly o Evidence of further reading beyond materials provided which were used in an appropriate context o Data is effectively analysed and appropriate assumptions/conclusions are reached	o Inclusion of adequate sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas o Use evidence/calculations to support claims/assertions/ideas, mostly clearly and convincingly o Evidence of further reading beyond materials provided o Data is analysed and the assumptions/conclusions that are reached are mostly appropriate	o Inclusion of some sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas o Use evidence/calculations to support claims/assertions/ideas, at times clearly and convincingly o Limited evidence of further reading beyond materials provided o There is an attempt to analyse data is and draw assumptions/conclusions
	Critical Evaluation	o Moved beyond description to an assessment of the	o Mostly description but some assessment of the value or significance of	o Only description with minimal assessment of the

		value or significance of what is described	what is described	value or significance of what is described
Written communication	Structure and Presentation	○ Ideas are presented in paragraphs and arranged in a logical structure that is appropriate for the assignment ○ The introduction clearly outlines how the essay/report will deal with the issues ○ The conclusion summarises all the main points clearly and concisely ○ All calculations, formulas and methods are clearly structured, clear to follow and correct ○ Tables and graphs are effectively constructed and/or described, including appropriate headings, units and scales. ○ All sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment ○ The introduction adequately describes how the essay/report will deal with the issues ○ The conclusion summarises most of the main points clearly ○ Calculations, formulas and methods are mostly structured, clear to follow and correct ○ Most tables and graphs are well constructed and/or described ○ Most sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure ○ The introduction mentions how the essay/report will deal with the issues ○ The conclusion summarises some of the main points clearly ○ Calculations, formulas and methods are not always structured, clear to follow and correct. ○ Some tables and graphs are well constructed and/or described but contain some errors ○ Some sources are referenced correctly in the agreed format with occasional errors
	Language and Style	○ No spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout ○ Writing style consistently clear, appropriate for scientific documents and easy to follow ○ Accurate and consistent use of technical language and vocabulary	○ Minimal spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout ○ Writing style mostly clear, appropriate for scientific documents and easy to follow ○ Some attempts of using technical language and vocab alary, but not always accurate	○ Some spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout with occasional errors ○ Writing style moderately clear, appropriate for scientific documents and easy to follow ○ Use of simple language and vocabulary effectively but struggles to use technical language

Glossary of Keywords – add your own

Word	Definition	Symbol /Formula/Value	Units (SI)
Pressure	Physical magnitude expressing the force exerted over a certain area	P =F/A	[Pa]=[N/m^2] Pascal= Newton/square metre
Giga-	Prefix to a unit indicating 10^9 or 1,000,000,000 times the unit that follows	G as in GPa= 10^9 Pa	
Nano-	Prefix to a unit indicating 10^{-9} or 0.000,000,001 times the unit that follows	n as in nm= 10^{-9} m	
Area of a circumference	$A = \pi r^2$		[m^2] Square metre
Volume of a cylinder	 Area of circumference × height of cylinder: $V = \pi r^2 h$		[m^3] Cubic metre
Gravitational field strength	Acceleration towards the Earth of an object near its surface	g = 9.8 m/s^2~ 10 m/s^2	[m/s^2] (acceleration units)
Angstrom	Length unit commonly used in Solid State Physics and Crystallography to refer to atomic bond lengths 1 Å = 0.1 nm =0.000,000,000,1 m		Angstrom is a length unit

Tutorial 1 – Diamonds and High Pressure

What is the Purpose of Tutorial 1?

- To introduce the tutor and the course
- Why are diamonds special?
- To understand the concept of High Pressure
- Scientific Paper Writing 1: identifying the structure and style of a research paper

Activity 1

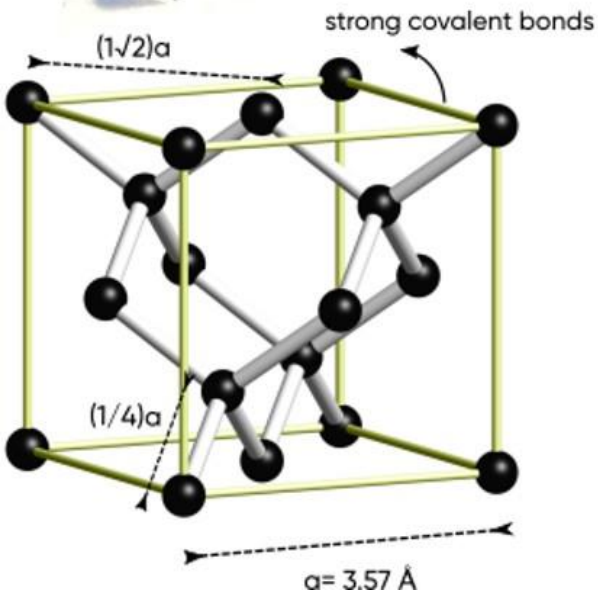
Watch the following video:

https://www.youtube.com/watch?v=FBzv8pQYcdA

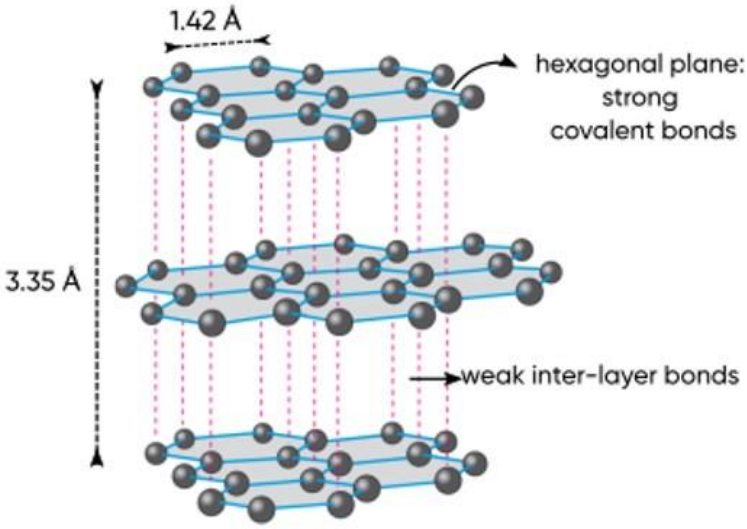
Look at the images on the cover of Tutorial 1. What are diamonds used for? Based on those uses, name at least two properties of diamonds.

CARBON ALLOTROPES: so similar…yet so different!

Diamond



Graphite



	Chemical Elements	No. of nearest neigh-bours	Distance be-tween near-est neigh-bours (nm)[1]	Colour	Hardness (Mohs scale)	Electrical conductivity	Applications
Diamond					10 (maxi-mum)		High Pressure, …
Graphite						Conductor	

Activity 2 Testing Pressure

Work in pairs: what makes the depth of the polystyrene hole deeper? What makes it shallower?

How would you express your empirical observations through a mathematical formula?

Let' s practice! What is the pressure, in Pa, exercised by…

- Your body lying in bed?

- You standing on your bed? And if you stand on one foot?

- An elephant on a stiletto

[1] Make sure that you use the correct units!

Scientific Paper Writing 1 - Identifying the structure and style of a scientific paper

STRUCTURE	STYLE
• How is the text organised? • List the sections and subsections in order • How is the content different in each of those parts?	• Is the text fact-based (objective) or opinion-based (subjective)? How do you know? • What sort of vocabulary is used? • Provide examples of: verbs, nouns, adjectives, adverbs

Tutorial 1 – Baseline Test

Write a 350 (± 50) word scientific text on the different ways diamonds are produced. You can base your text on the following resources and/or complement them with other you find.

1) http://www.bbc.com/earth/story/20170301-the-secret-of-how-diamonds-are-made-by-nature
2) https://www.youtube.com/watch?v=O-1oksDmNBU ~5 min (natural and synthetic CVD)
3) https://www.youtube.com/watch?v=xfoFrEbWn_M ~3 min (natural and synthetic)
4) https://www.youtube.com/watch?v=-ZNyGrkFo4w ~4 min (synthetic HPHT)
5) https://www.youtube.com/watch?v=vHPOp69SO9E ~3 min (natural)

Use the guidelines below to help structure your text:

- **Title:** The title tells the reader key information about the content and purpose of the text that follows.
- **Introduction (1 paragraph)**: Introduce the context of the main topic: e.g. What are diamonds? What is their composition and structure? And their properties and applications?... Research the topic based on what we have seen throughout the tutorial, the resources above, or others you may select. Remember to reference your sources (check Appendix 1 to see how to do it).
- **Body (2-4 paragraphs):** Describe the main processes involved in the production of diamonds, whether they are natural diamonds or man-made synthetic diamonds.
- **Summary and Conclusion (1 paragraph):** Summarise the most important points of your text and the main conclusions. Are there any open questions left for future investigations? After the research you have done, can you come up with any of your own?
- **Bibliography:** Remember to reference your sources (check Appendix 1 to see how to do it).

Notes

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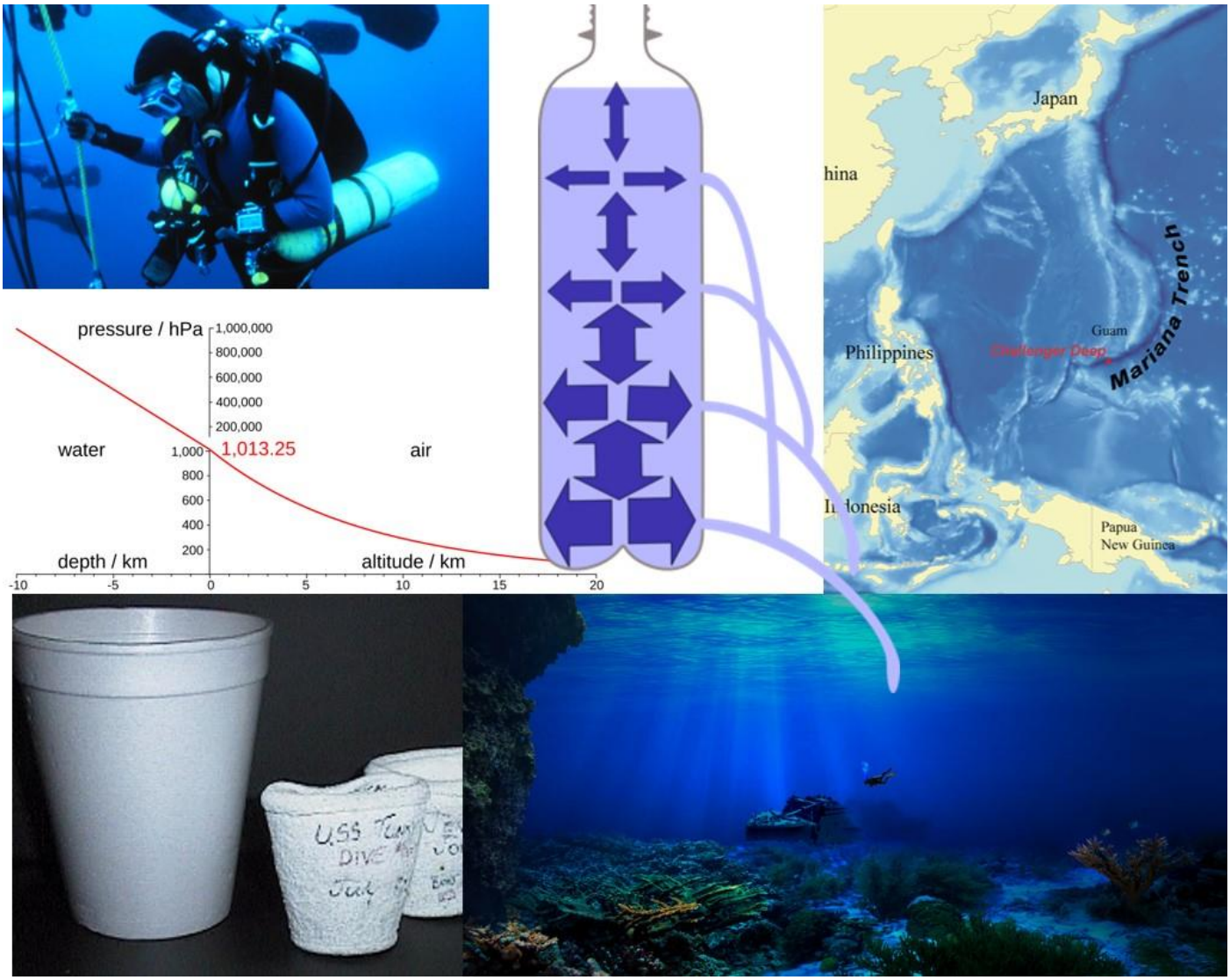
Tutorial 2 -The Impact of Pressure

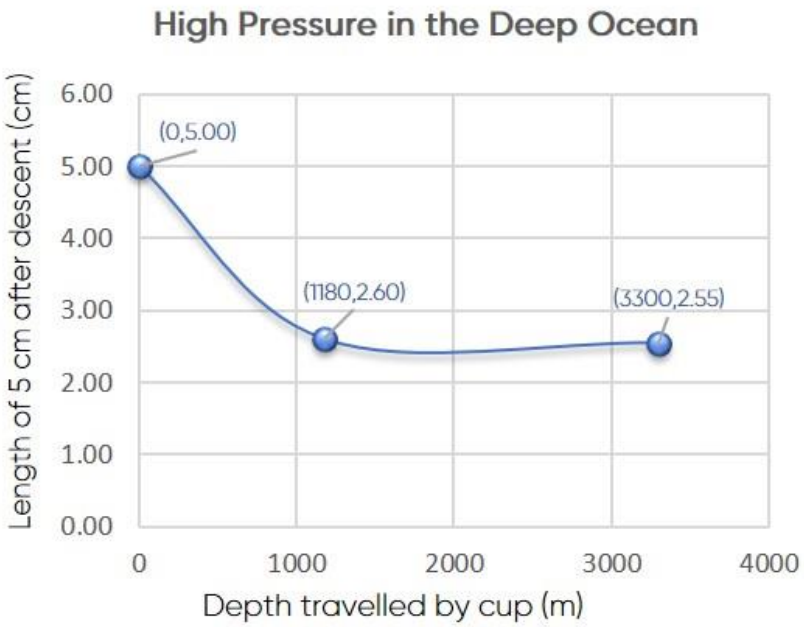


What is the Purpose of Tutorial 2?

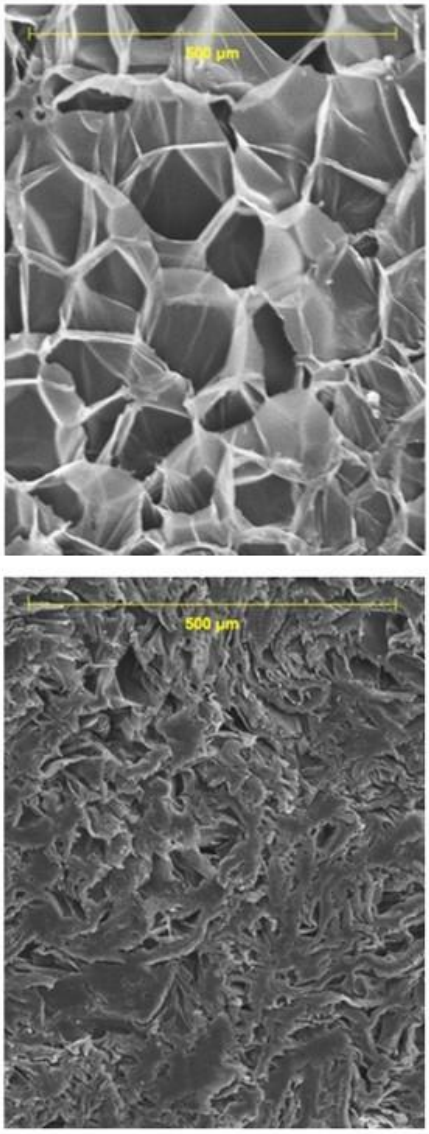
- To understand the impact Pressure and High Pressure can have
- To describe the difference between Uniaxial and Hydrostatic Pressure
- Scientific Paper Writing 2: structuring a text correctly

Activity 1 UNDER THE SEA

Look at the graph and photograph below. Describe what the graph depicts. How much smaller is the cup at 3300 m below the sea compared to its original size?



Measurements of the change in size of a polystyrene cup as a function of the depth the cup reached under water (graph above). The cup before and after the deep-sea compression (image below).



Electron microscopy images of the cup microstructure at 0 m sea-level (image above) and after compression in the deep sea (image below).

Adapted from *https://www.sciencefriday.com/educational-resources/high-pressure-in-the-deep-ocean*

List the observable effects of High Pressure on the polystyrene cup from the figure above. Why do you think the length of the cup does not decrease so strongly from about 2000 m on? *(Hint: inspect the electron microscope images on the right-hand side).*

Math challenge!

Calculate the pressure in GPa on the cup at 2000 m below the water surface, knowing that the density of water is ~1 kg/l. How much larger is that than the atmospheric pressure?

Hint 1: remember that density = mass/volume and 1 l = 1 dm^3

Hint 2: apply your knowledge of basic geometry! (check The Glossary)

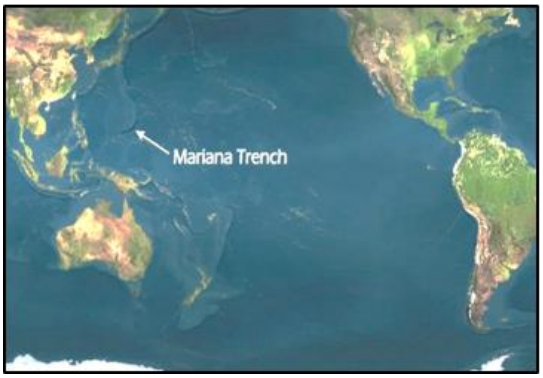
And remember!!! All units should be in the International System (kg, m, s...)

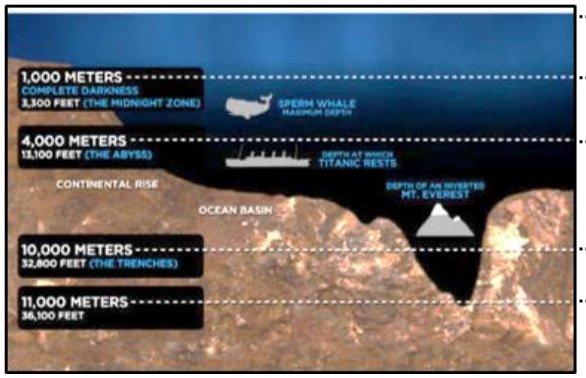
Look at the sketch of the bottle on the cover of Tutorial 2. What is happening? Why? What are the arrows illustrating? Why are they drawn of different thickness?

The deepest point on the Earth' s surface, the Challenger Deep in the Mariana Trench, features a Pressure of ~0.11 GPa

https://www.youtube.com/watch?v=Y2tm40uMhDI

https://www.youtube.com/watch?v=JMVXSZUXPf0





Pressure

1 bar=10^5 Pa

10^7 Pa=0.01 GPa

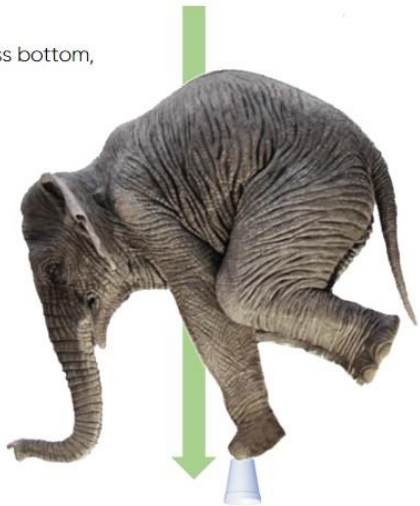
10^8 Pa=0..11 GPa

Activity 2 HYDROSTATIC PRESSURE vs UNIAXIAL PRESSURE

Calculate the pressure exerted by the elephant on the examples below and sketch how the glass would look under that pressure. How is that different from the cup immersed in water from the previous example? What do the arrows stand for?

Mass of the elephant,
m= 6000 kg

Radius of the glass bottom,
r= 2 cm



Polystyrene cup under pressure:

Glass under pressure:

Sketch the polystyrene cup before and after immersing it at a few thousand metres under water. How would you now draw the arrows?

Tutorial 2 - Scientific Paper Writing 2

2.1 PEER REVIEW

Based on the characteristics of scientific writing discussed previously, you will assess the text written by your peer. Don´t forget to provide proof of your evaluation (examples in the text).

2.2 THE STRUCTURE OF A SCIENTIFIC PAPER

You will be given a guide to write a scientific paper and asked to make one/two slides summarising the most important points of one or two of the sections (Title, Abstract, Introduction, Experimental Methods, Results and Discussion, Conclusions, and Bibliography). Your work will be much stronger and will qualify for extra merit if you include examples you find in the real paper discussed in Tutorial 1.

Notes

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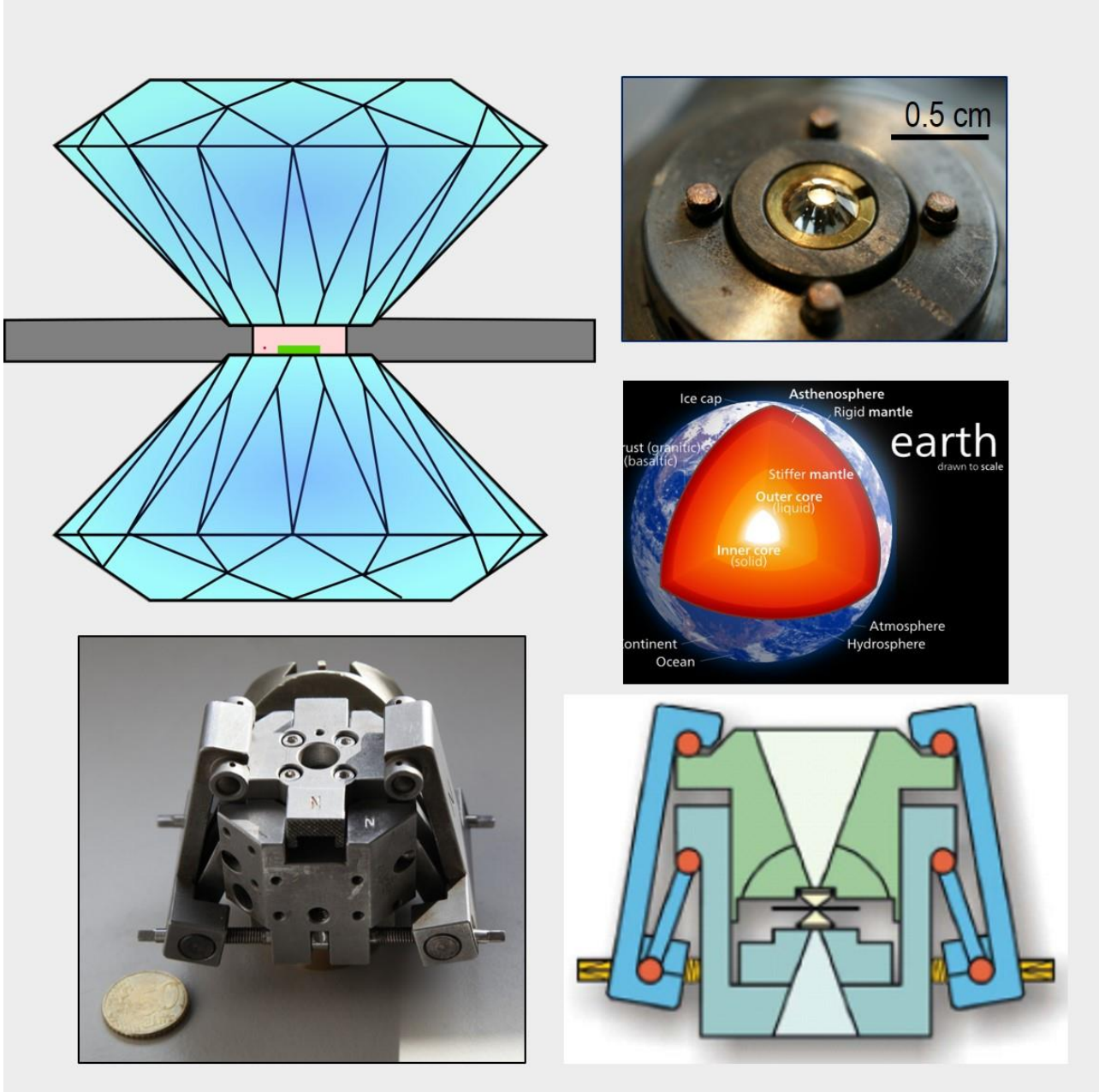
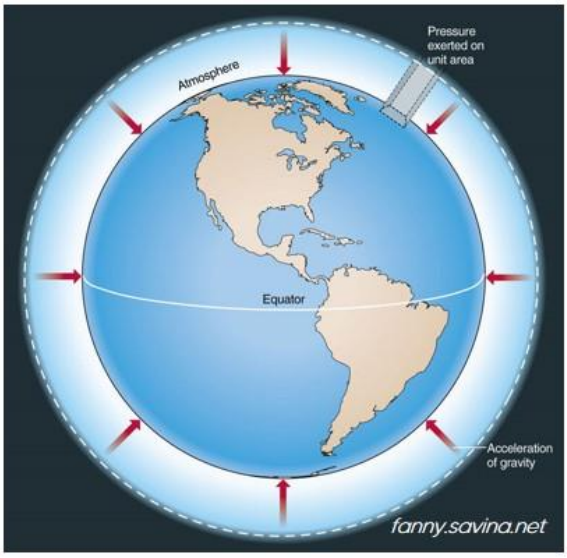
Tutorial 3 –Producing High Pressure



What is the Purpose of Tutorial 3?

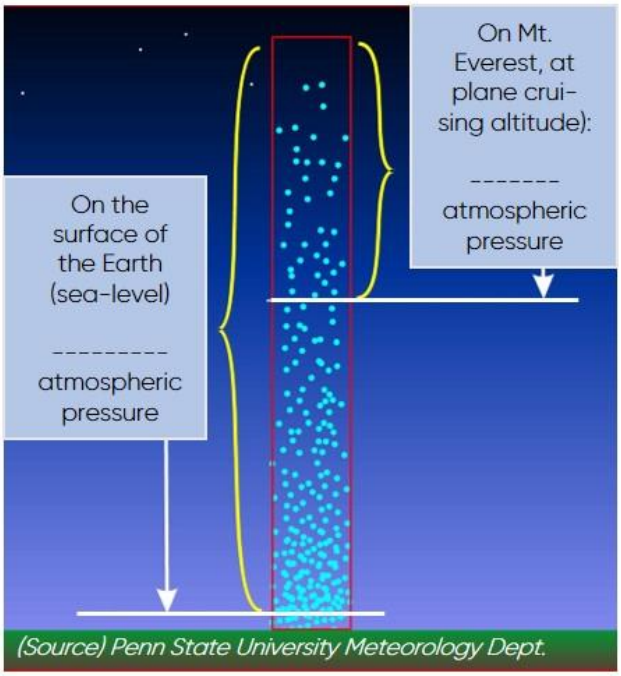
- To identify places inside Earth and the Universe that will manifest High Pressure conditions and why
- To introduce the way to produce High Pressure in the lab: the Diamond Anvil Cell (DAC)
- Scientific Paper Writing 3: describing the methods used in an experiment

Activity 1 IDENTIFYING PRESSURE AROUND US

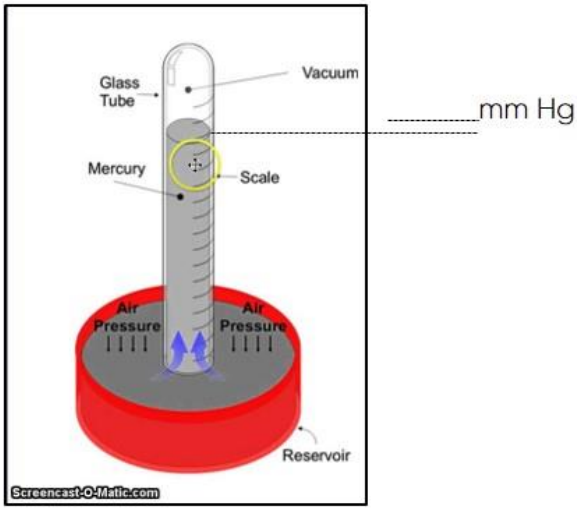


Atmospheric Pressure is...

Atmospheric Pressure and Altitude



Measuring Atmospheric Pressure



Why do our ears pop in an airplane? Why do our water bottles look crumbled when we are back down from the flight?

How would you explain the medical condition High Blood Pressure?

MIND THE UNITS! And don't be fooled…they are all pressure units!

The sea-level average Pressure is…

1 atm = 1.01325 bar = _____mbar = 101,325 Pa = _____mmHg

…and 1 bar = 0.0001 GPa = 100,000 Pa

Activity 2 PRESSURE BEYOND HUMAN EXPERIENCE: gigapascals (GPa) inside Earth and other planets

1 GPa=10,000 bar

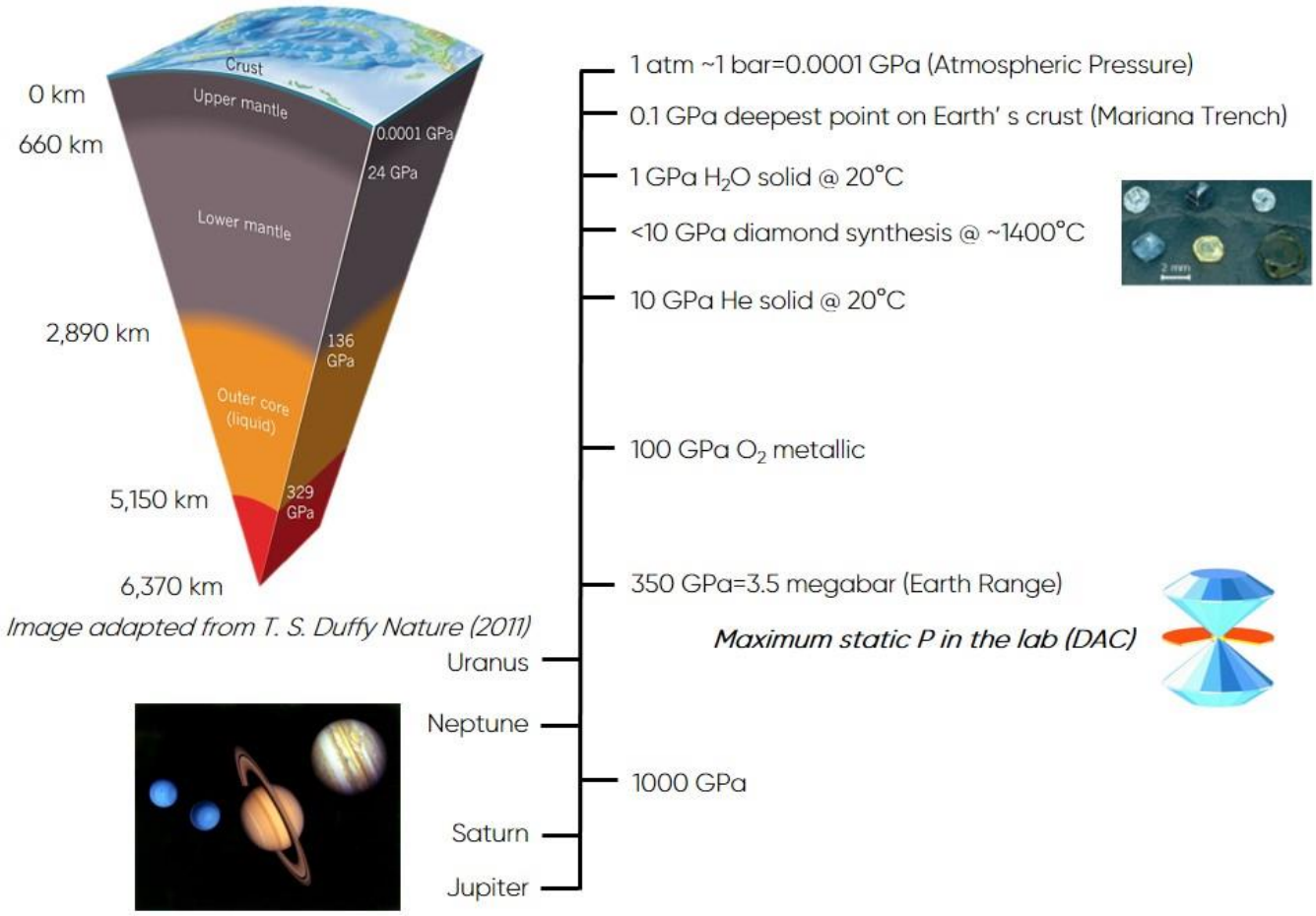


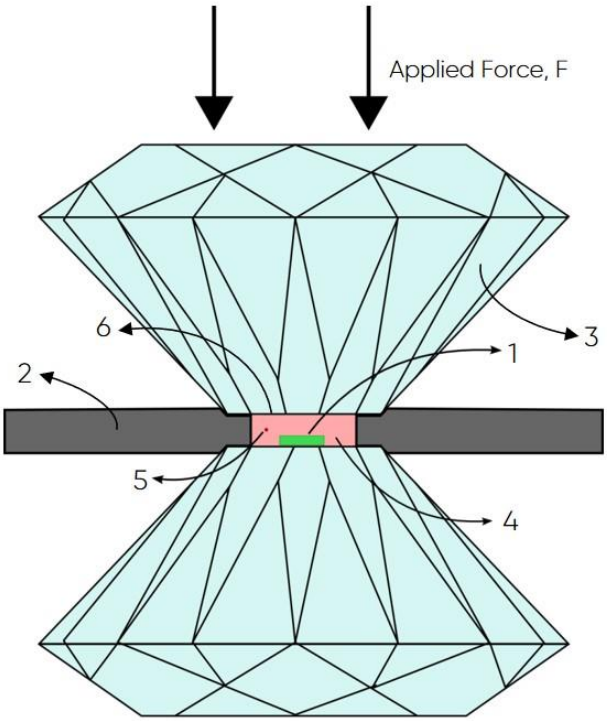
Image adapted from T. S. Duffy Nature (2011)

Pressure Beyond Human Experience: gigapascals (GPa) in the lab

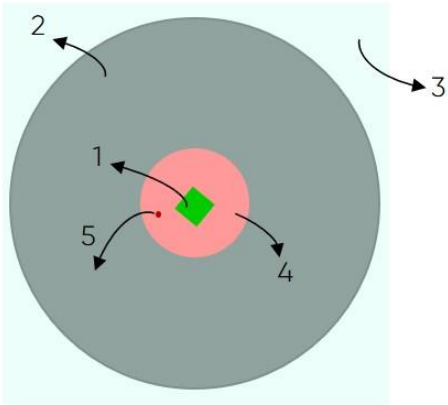
The Diamond Anvil Cell (DAC)

Match each component of the DAC to the correct number

Cross-section view



Top view



___ Brilliant-cut diamond

___ Diamond culet

___ Hard-metal gasket

___ Sample (material investigated)

___ Sample-chamber, filled with Pressure Transmitting Liquid

___ Ruby crystal sphere (pressure-gauge)

Discuss in pairs: make a reasonable assumption as to what the radius of the diamond culet and the force applied could be if I want to simulate the pressure at the Earth's core (~350 GPa). How much larger is that pressure to the pressure we experience sitting in this classroom?

Activity 3 Producing solid metallic hydrogen!!

Take notes while listening to one of the most important scientific discoveries of the last decades. Or is it?

https://www.youtube.com/watch?v=dHLKwo6W9D8

https://www.youtube.com/watch?v=2rX1xtdfByo

https://www.youtube.com/watch?v=kV3FY4q1xjY

Tutorial 3 –Scientific Paper Writing 3

Scientists believe that silicates make up a large amount of the material of the Earth' s lower mantle, at about ~2,900 km below the Earth' s crust. You are an Earth Scientist that wants to replicate in your laboratory the pressure conditions at that distant point inside Earth by applying up to 140 GPa to $MgSiO_3$ (a silicate compound). Describe how you perform your experiment using a Diamond Anvil Cell (DAC).

Your readers are not pressure specialists and do not know what a DAC is, so be sure to introduce your experimental device appropriately.

Guidelines:

- Use what you have learnt is included in the Methods section of a scientific paper
- Use examples from real papers to inform your writing.
- Estimate the size of diamond culets and the sample size you will use to reach the desired pressure. The maximum force exercised by your DAC is 10,000 N.
- For more details on how the DAC works, refer to the handbook, the internet, or the videos above.

Notes

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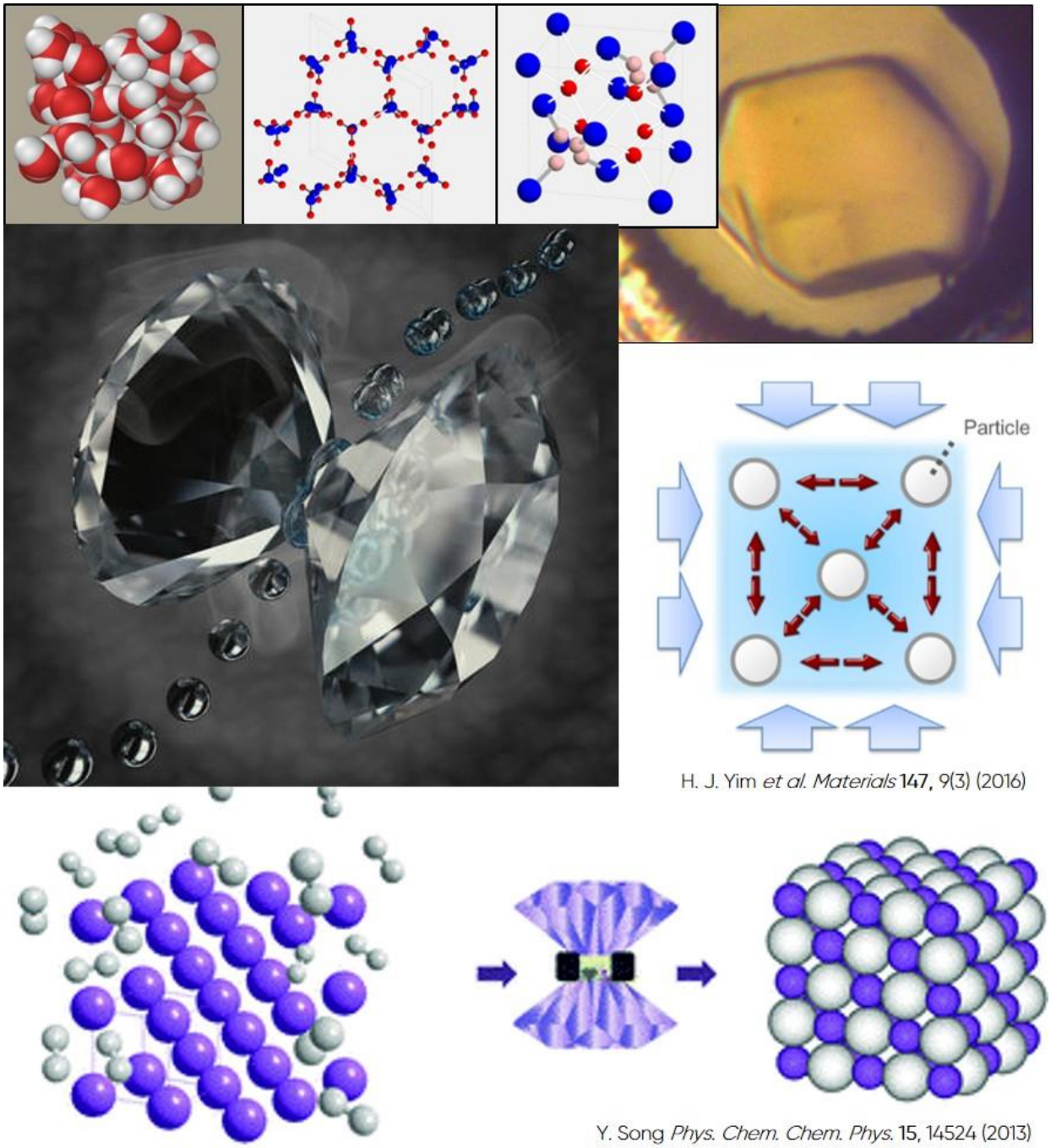
Tutorial 4 – High Pressure Makes Gases Solid!

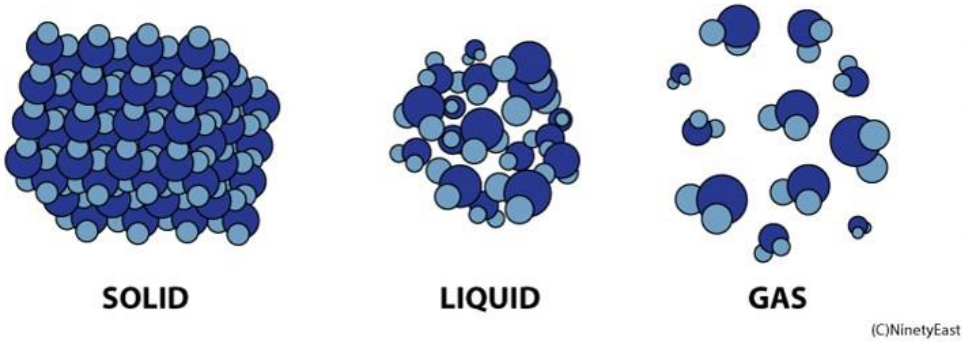


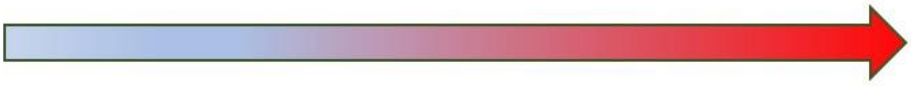
What is the Purpose of Tutorial 4?

- To describe how Pressure can trigger Phase Transitions
- To interpret and extract data from Phase Diagrams
- Scientific Paper Writing 4: interpreting and describing scientific data in the form of graphs

Activity 1 WATER UNDER PRESSURE

Which way should the arrow be drawn for the case of Pressure and Molecular Interactions? Why? Draw the arrows in the space allotted and reason your answer in the space to the right.





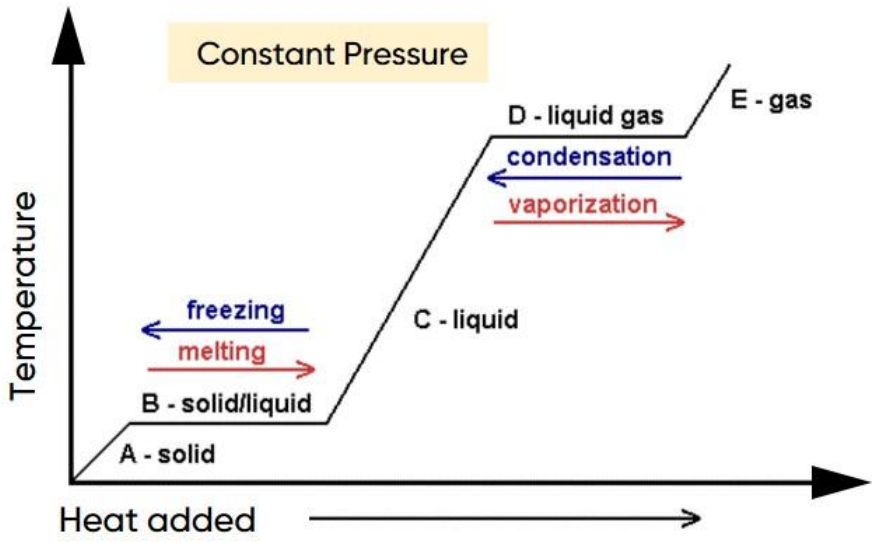
Temperature

Molecular Motion

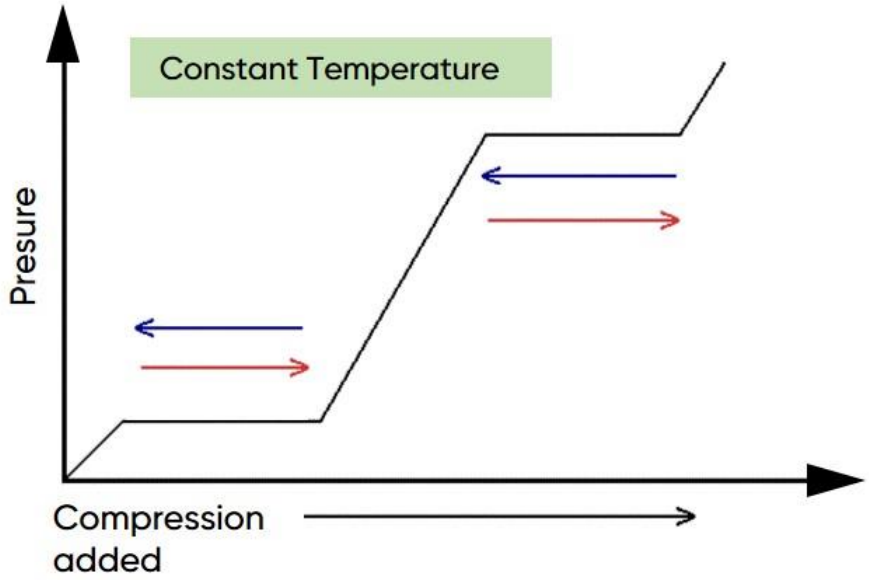
Pressure,

Molecular Interaction

Describe the graph below:

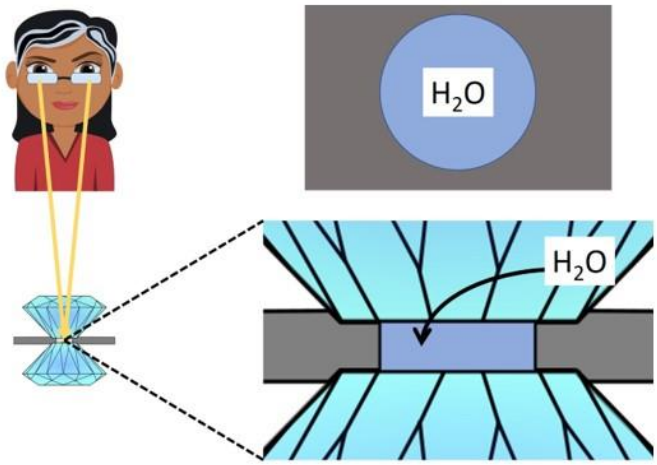


Instead of adding heat you are increasing compression (and thus, pressure) over a gas. How would you now label the graph below?



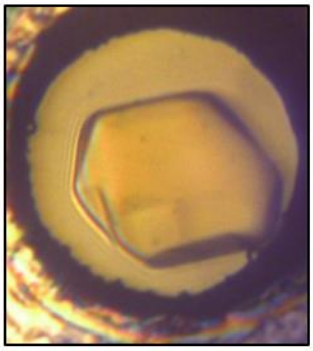
WARM ICE??

Discuss in pairs how you would perform the experiment below



Cartoon showing the setup for pressurizing H_2O using a DAC

Temperature =25 °C
Pressure > 1.1 GPa



Courtesy of K. Syassen, Max Planck Institute for Solid State Research, Germany

Optical microscope image of the DAC chamber during the High Pressure experiment. It shows a solid H_2O crystal (ice) coexisting with its liquid phase at the moment of the phase transition.

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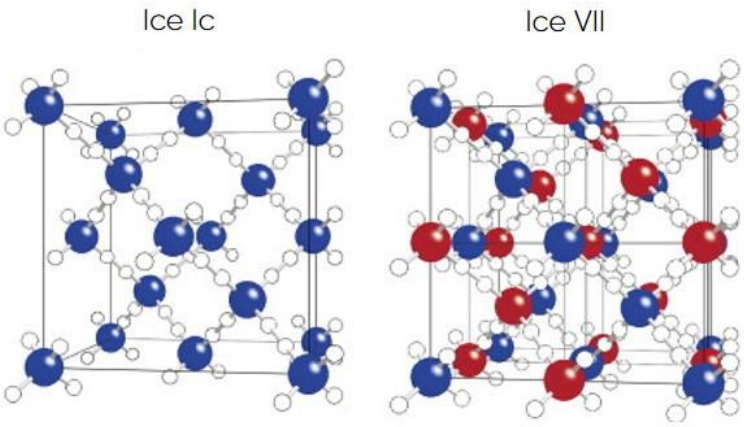
Activity 2 Ice alright... But is all ice the same??

Inspect the table below showing liquid H_20 (water), an ambient pressure form of ice, and a High Pressure form of ice. How are the two forms of ice different? What would the implications for the seal be if lying on pressurized ice?

	TEMPERATURE (°C)	PRESSURE (atm)	PRESSURE (Pa)	DENSITY (g/cm^3)	Form of H_2O
	25	1		0.997	
	-25	1		0.916	
	25	~11,000	1.1×10^9 (1.1 GPa)	1.66	

Study the representation of the microscopic structure of Ice Ih ("normal" ice) and Ice VII (high density ice). State the similarities and differences.
**Note: both red and blue spheres denote oxygen atoms. White spheres represent hydrogen atoms.*



K. Umemoto *et al. Chemical Physics Letters* **499**, 236 (2010)

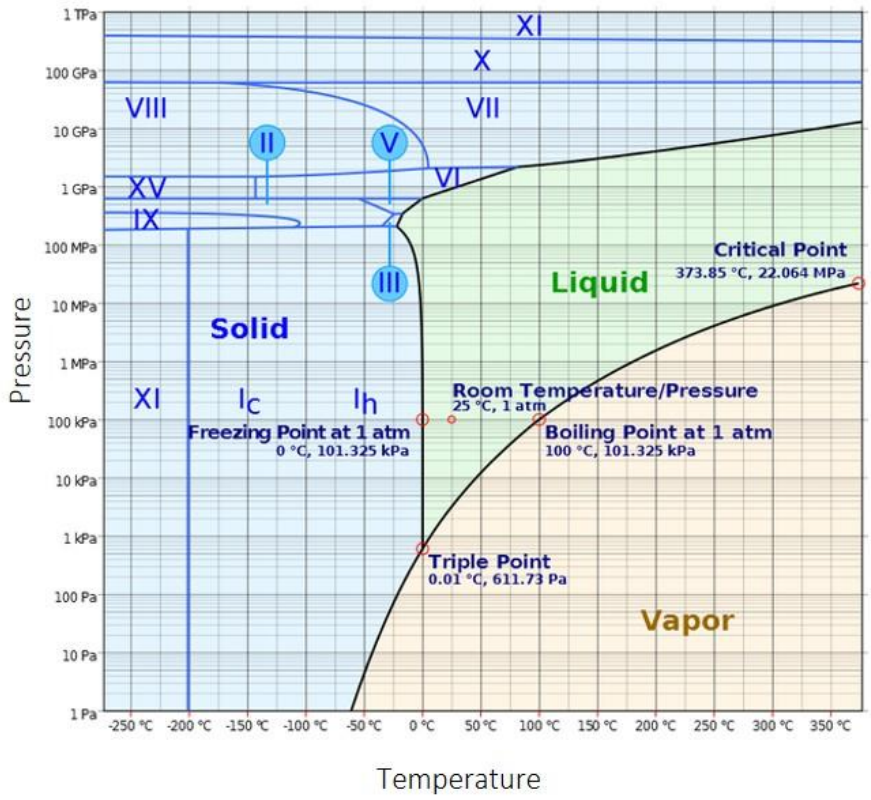
INTRODUCING PHASE DIAGRAMS

A Pressure Temperature phase diagram (P-T phase diagram) for a specific substance is like a map, it gathers all the information regarding the physical state at which a substance can exist in equilibrium.

Fill in the table below by extracting the information you need from the P-T phase diagram

SPECIAL NAME	PHASE	T (°C)	P (Pa) or (atm)
Ambient Conditions			
Freezing point	Liquid-solid transition	0	
Freezing point	Liquid-solid transition	25	
Freezing point	Liquid-solid transition	50	
Freezing point	Liquid-solid transition		
Boiling point	Liquid-gas transition	100	
Boiling point	Liquid-gas transition		30 kPa (Mt Everest)
N/A	Liquid		
N/A	Solid, Ice Ih		
N/A	Solid, Ice VII		

Pressure Temperature (P-T) phase diagram for H_2O



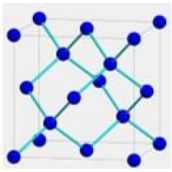
Tutorial 4 –Scientific Paper Writing 4

You have performed a High Pressure experiment to study how the volume of silicon (Si) changes when increasing hydrostatic pressure. The results of your experiment are gathered in the graph below, which shows the relative volume ($V_{final}/V_{initial}$) as a function of pressure. Describe the graph as a scientist would in her/his research paper. Mention all phases depicted in the graph but go into more detail only for phases I, XI and V, for which you have some structural information.

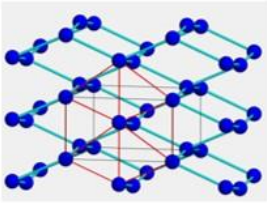
Guidelines:

- State what is being measured (dependent variable) as a function of what (independent variable) in which material.
- Describe the general trend that the results show and the most remarkable features.
- Write a more detailed account of the three Si phases for which you have information.

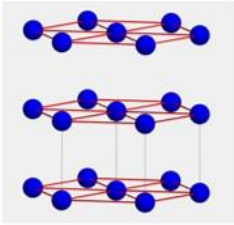
Si-I
0-12 GPa
Cubic structure

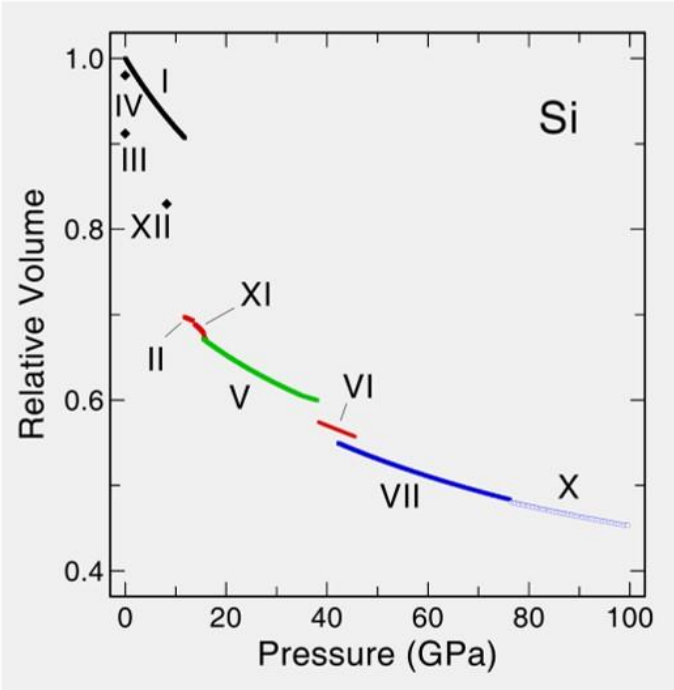


Si-XI
13-16 GPa
Orthorhombic structure



Si-V
16-38 GPa
Hexagonal strucrue





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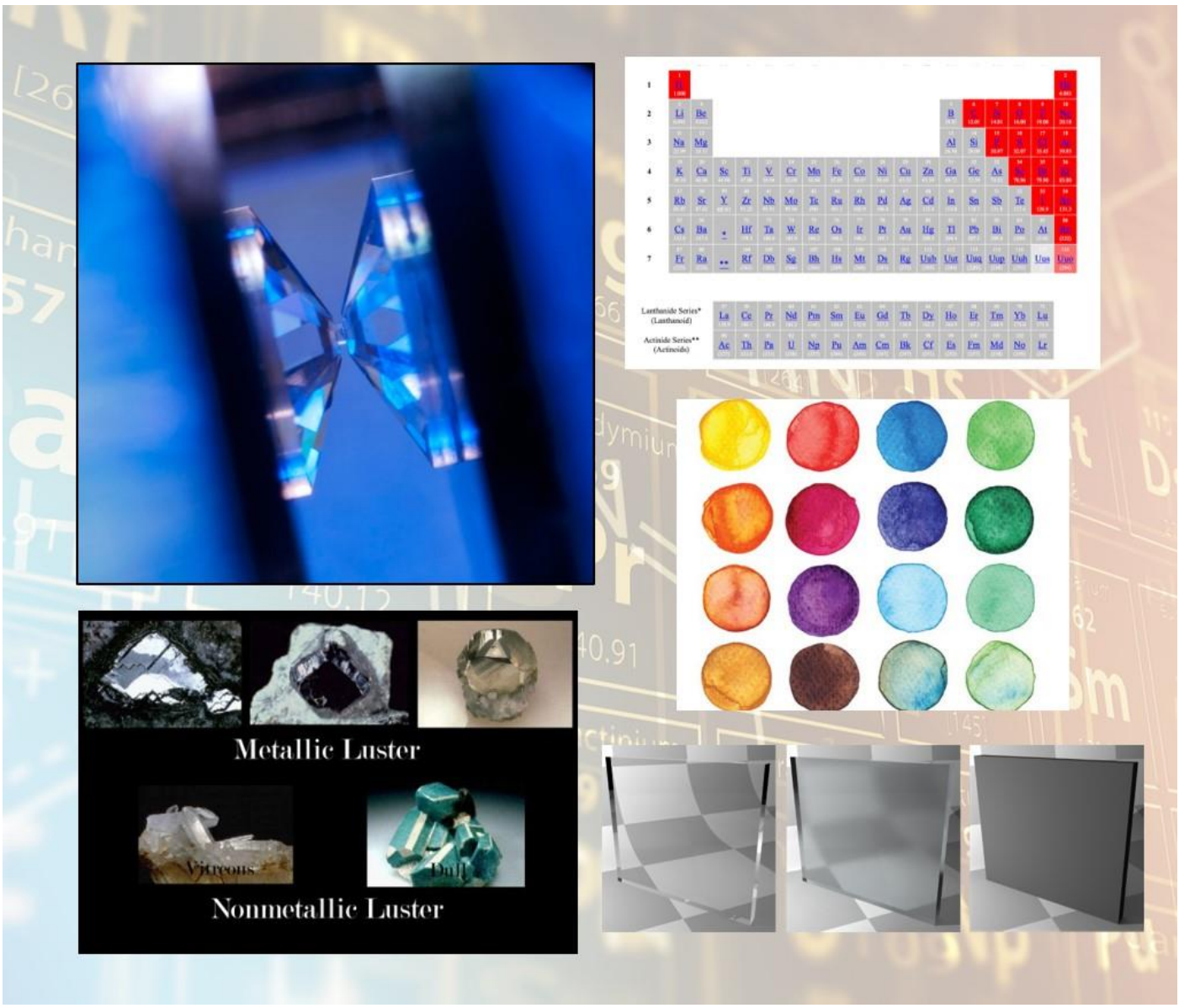
Tutorial 5 – Changing Colours and Conductivities with High Pressure

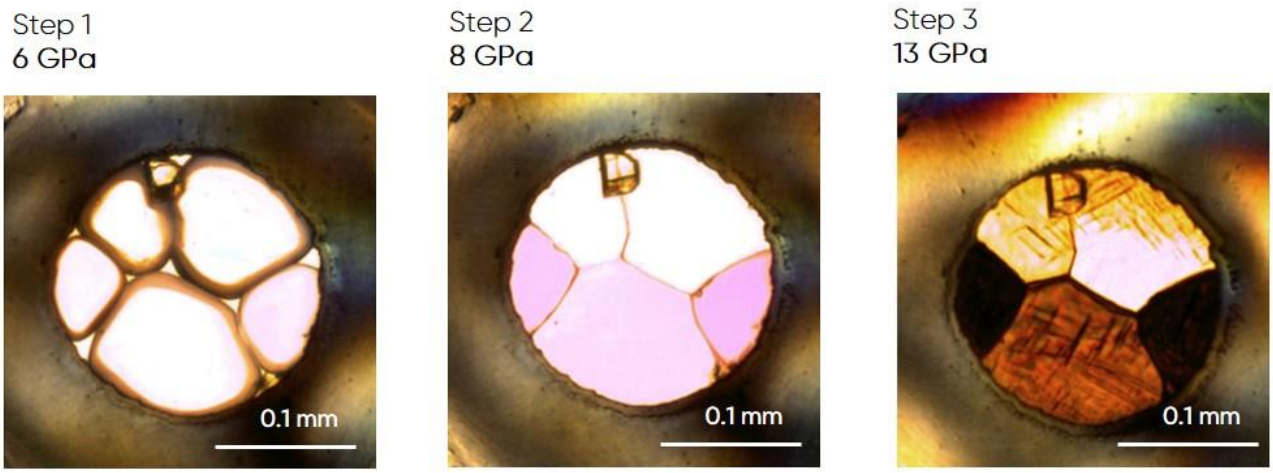


What is the Purpose of Tutorial 5?

- To introduce optical and electrical properties of materials
- To identify the effects of High Pressure in the optical and electrical properties of materials
- Scientific Paper Writing 5: Final Assignment

Activity 1 Making gases metals

You are pressurizing oxygen gas (O_2) in a DAC at room temperature (~25 °C) and observe the evolution of your sample through an optical microscope (see the images below). Describe what is happening.

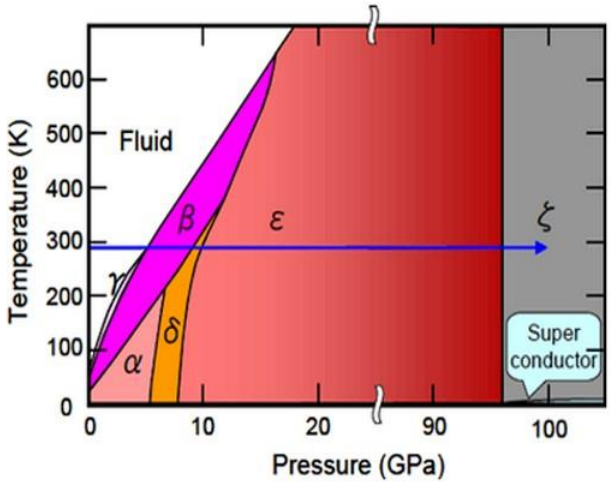


Courtesy of K. Syassen, Max Planck Institute for Solid State Research, Stuttgart, Germany

What will you observe if you now slowly de-pressurize?

The Pressure-Temperature phase diagram for oxygen is shown below. What phase of oxygen do you obtain at each of the registered steps in the experiment from above? Complete the chart.

[*note: T(°C) = T(K) -273]



Y. A. Freiman and H. J. Jodl, *Phys. Reports* 401, 1 (2004)

6 GPa	8 GPa	13 GPa
Oxygen _____ Phase _____	Oxygen ____-Phase (solid)	Oxygen _____ -Phase (solid)

MATCH THEM UP!

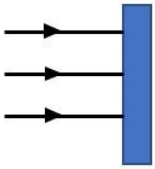
Match the optical properties on the left with their correct meaning on the right column

A) TRANSPARENT

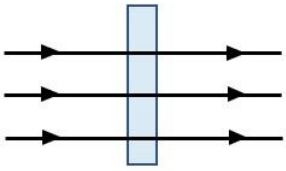
B) TRANSLUCENT

C) OPAQUE

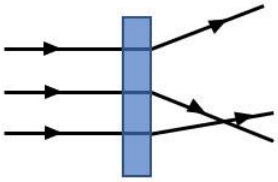
1. Light does not pass through. It is either reflected (metal) or absorbed (e.g. wood)



2. Light travels straight through

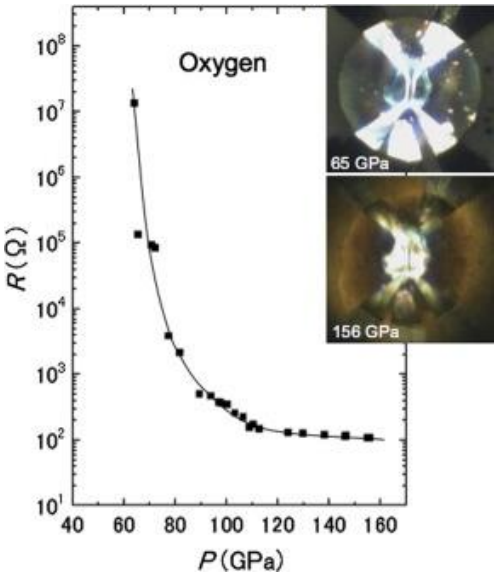


3. Light passes through but scattered at random positions



How would you qualify the **γ**-Oxygen, **β**-Oxygen and the **ε**-Oxygen phases in terms of their optical properties?

Researchers in Japan compressed oxygen well beyond 13 GPa and recorded the electrical resistance in the graph below. Describe the observed results:



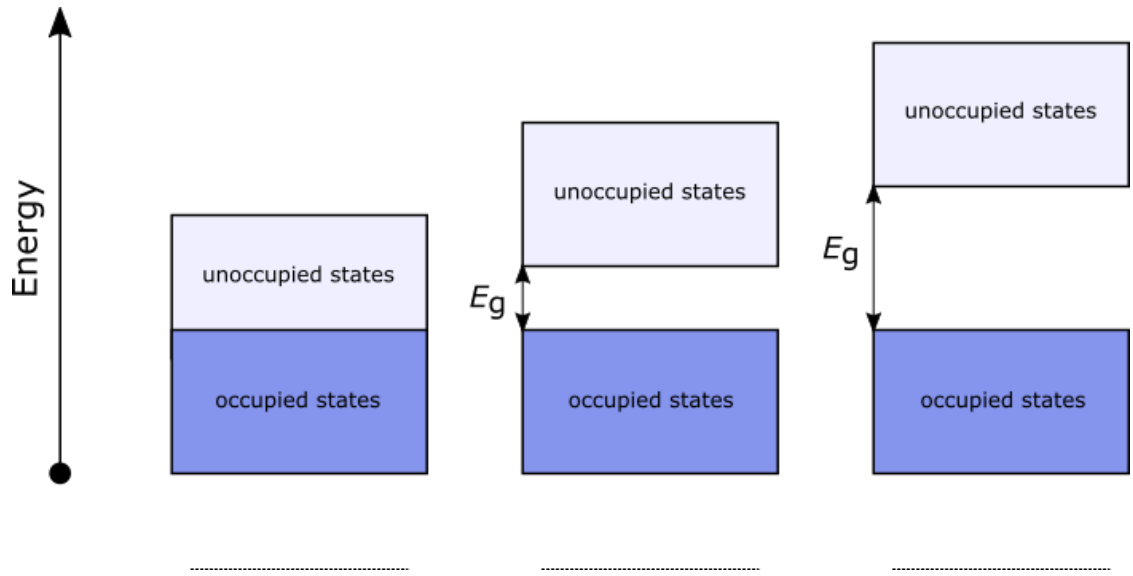
Shimizu *et al.* "Superconductivity from insulating elements under High Pressure", *Physica C* **514,** 46 (2015)

What would you expect the optical properties and colour of this new solid oxygen to be?

What do you think the images on the right of the graph above tell us? Look at the images of the diamonds on the cover of the Handbook. Do you see any similarities?

Activity 2 On metals, insulators, semiconductors and High Pressure

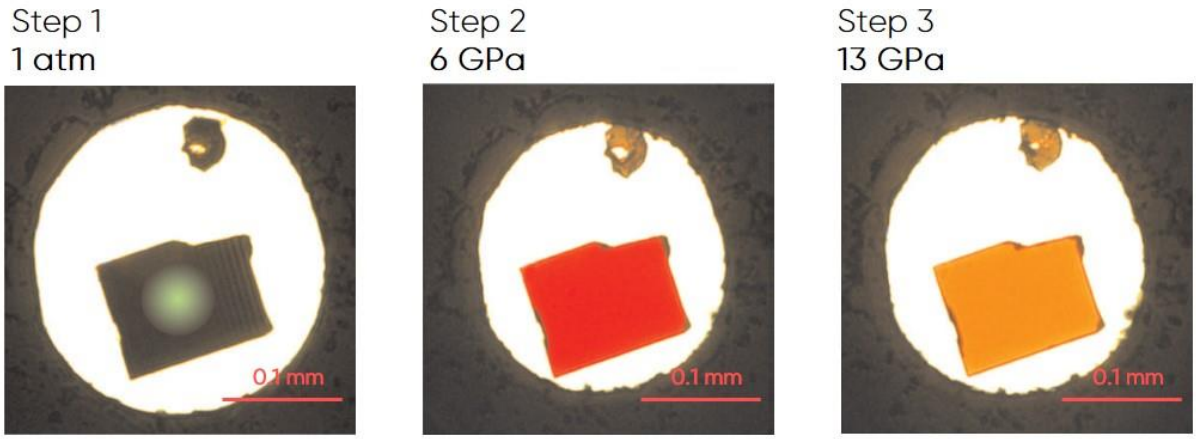
Crystalline metals can be classified into metals, insulators and semiconductors depending on the magnitude of the Energy Band Gap (E_g), i.e. the difference in energy between the top of the valence band and the bottom of conduction band.



Fill-in the table below:

	Optical Properties	Electrical Properties	Energy Band Gap (E_g)
	Opaque, shiny	Low *R*	
(Crystalline) Insulators (diamond, quartz, NaCl...)	Transparent, translucent	High *R*	> 3 eV
Semiconductors	Varying colours from translucent to opaque		0 to 3 eV

GaAs is a semiconductor material which shows an opaque, dark green colour at ambient pressure. Its Energy Band Gap is 1.43 eV under those conditions. Observe the change in colour of the GaAs sample as it is pressurized.



Adapted from A. R. Goñi and K. Syassen, (1998) *High Pressure Semiconductor Physics* I, Academic Press Ch 4

How do you think the Energy Band Gap is being modified by Hydrostatic Pressure?

Draw the energy band diagram showing the evolution of the Energy Band Gap with increasing pressure. Will the GaAs sample be a better or a worse conductor of electricity at higher pressure?

Tutorial 5 –Final Assignment

You are a researcher that has conducted an investigation on how Material X behaves under High Pressure. You have performed a number of experiments of pressurizing Material X using a Diamond Anvil Cell. Write a scientific paper (2000 ± 200 words) reporting your experiments and your findings to the scientific community (not necessarily High Pressure experts).

Note: Material X can be a real compound (given examples or others) or a fictitious one. You have the liberty to give Material X the mechanical, optical and electrical properties you want and decide how they will be modified under High Pressure. You only need to make sure your choices are well-founded and that you are able to describe the properties and their change with pressure.

Take into account the work done in class, your homework, and the feedback given. Remember to use the structure appropriate to a scientific paper:

- Title

- Abstract
  Brief summary of your study and main conclusions

- Introduction
  Give information of what is already known about Material X: structure, properties, applications… Introduce High Pressure. How do you define it, what is the effect of High Pressure in materials in general? What do you want to study by applying High Pressure to Material X and why? Remember to reference appropriately (see Appendix 1)

- Methods
  Describe how you performed your experiments (what diamond sizes and why, which pressure you wanted to achieve, and thus the sample size and preparation…)

- Results and Discussion
  Describe what you observed. You want to support your evidence using images, graphs and/or tables. What do your findings tell you about the effect of High Pressure in this material? How does this compare to other materials relevant to your study? Is this something you expected? What do you think is the reason for this behaviour (you can refer to other people's findings to support your reasoning)? You can also speculate and point at future possible experiments that would help clarify these assumptions.

- Summary and Conclusions
  Brief summary of your experiment and main findings. Does your study clarify any prior existing questions? What could be done in the future to extend the knowledge or make the experiment even better? (e.g. technical improvements that could lead to a better experiment- reaching even higher pressures, for example)

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Tutorial 6 – Feedback tutorial

What is the Purpose of Tutorial 6?

- To receive feedback on final assignments.
- To share examples of best practice with the other pupils in your group.
- To write targets for improvement in school lessons.
- To reflect on the programme including what was enjoyed and what was challenging.

Final assignment feedback

What I did well...	What I could have improved on...
•	•
•	•
•	•

My target for future work is...

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
•   •   •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. **A marker in your assignment**: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].

2. **Bibliography**: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.

    a. **Websites** – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

    E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

    b. **Books** – Author, date published, title of book (in italics), pages where the information came from.

    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. **Articles** – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

    E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

Appendix 2 – Using the VLE

VLE username	
VLE password	

Please remember the following key details...

- You are able log into the VLE either through the link on our website (www.thebrilliantclub.org) or going directly to the VLE site at (https://portal.thebrilliantclub.org/sign-in).
- Please update your profile with your full name and email address- this will allow you to retrieve forgotten passwords or usernames
- If you forget your log-in details you can request them to be emailed to you by clicking the link on the VLE home page. (If you are still having problems you can email: schools@thebrilliantclub.org)

What is the VLE?

The VLE is a virtual learning environment for all pupils on Uni Pathways it is used for:

- messaging your tutor
- submitting homework
- submitting your final assignment
- accessing resources for your tutorials
- finding out more information about university and careers

How should I use the VLE?

The VLE is a professional academic environment in which pupils are able to message their PhD Tutor. Here are a few things to consider:

- Ensure you keep a professional tone in the messages you send to your tutors.
- Ensure you always reply to your tutors in a timely manner.
- Thank your tutor for the effort they are putting in to give you your feedback etc.
- Submit all homework to your tutor on time.

IMPORTANT: Final assignment

- When you submit your final assignment, please remember that you need to do so through the 'My Activities' tab and not as an attachment to a message.

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High Pressure Science: Why diamonds are a (scientist) girl's best friend!

Key Stage 4 Programme

researchersinschools.org