STUDENT LABORATORY WORKSHEET EXPERIMENT C:

GOLD COLORIMETRIC NANOSENSOR

Student name:……

Date:……..

AIM: - Understanding the effect of size on the properties of a familiar material such as gold
- Properties of colloids
- Optical properties of gold nanoparticles
- Understanding the use of gold colloids in biosensors and in particular for medical diagnostics

BEFORE YOU FILL IN THIS WORKSHEET:

- read the STUDENT BACKGROUND sheet
- ask your teachers questions if you have any

SAFETY NOTE: The experiments described in the following training kit use chemicals which need to be used according to MSDS specifications. Follow school lab safety guidelines. Personal protection must be taken as indicated. As with all chemicals, use precautions. Solids should not be inhaled and contact with skin, eyes, or clothing should be avoided. Wash hands thoroughly after handling. Dispose as indicated. All experiments must be conducted in the presence of an educator trained for science teaching. All experiments will be carried out at your own risk. Aarhus University (iNANO) and the entire NANOYOU consortium assume no liability for damage or consequential losses sustained as a result of the carrying out of the experiments described.

PROCEDURE

1. Gold and its properties. Fill in the table about the **properties of gold**

	COLOUR	CONDUCTIVITY & REACTIVITY	APPLICATIONS
BULK GOLD			
NANOGOLD			

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Add comments here if space in table is not enough:……

……

Q1. Can "bulk" gold have colours different from the normal golden colour? If yes, in what form?

……

Q2. What colour can a metal colloid be? Why?

……

……

2. Synthesize a gold colloid.

Follow the **student synthesis protocol for EXPERIMENT C** and write down your observations as the synthesis proceeds. *Read the table below before starting the synthesis so you know what to look for as the reaction proceeds*. Observe carefully the colour change during the time of the reaction.

Record your observations in the table below:

Colour of $HAuCl_4$ solution (before reaction)	**Colour *immediately* after the addition of the citrate**	**Colour of the final gold colloid**	**Did you notice any intermediate colours? Which one(s)?**	**Time of reaction**

Q3. Why do you think some intermediate colours are seen during the reaction?

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3. Learn the properties of a gold colloid.

Q4. A colloid is different from a solution. What is the difference?

…….

Q5. The presence of nanoparticles can be confirmed using a laser pen. Why?

…….

Q6. Are there any natural colloids? If yes, name a few.

……

Now use a **laser pen** to confirm the presence of gold nanoparticles in your sample and to test for other ones. Record your observations (**WARNING**: never look straight into a laser beam!).

Sample	**Observed effect**	**Additional comments**
Water		
Diluted milk[1]		
Gold colloid synthesized in class		
Salt solution		

[1] Use 2 droplets of milk in 150 mL of distilled water

Q7. Based on your observations, which of the materials you have tested is a colloid?

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4. Test the gold colloid as a colorimetric nanosensor.

MATERIAL NEEDED:

Chemicals:

- The gold colloid prepared in the synthesis (Part 3), should be about 15 mL
- 0.5 g of NaCl (Sigma Aldrich #S7653, 250g costs about 32 Euros), fine kitchen salt can be used as alternative
- 2 g of sugar
- 1 fresh egg
- 1 litre of distilled water

Glassware/labware:

- Eye protection
- Latex or nitrile gloves
- paper towels
- Cylinders: 10mL cylinder, 50mL cylinder and 500 mL cylinder
- Glass pipettes: 5 mL pipette and 25 mL pipette, 10 Pasteur pipettes
- 50mL Erlenmeyer flask or beaker
- 2 disposable plastic capsules for measuring solids
- Spatula
- Glass bottles: bottle 500mL, 2 small bottles 25 mL or 2 beakers of 25 mL
- 6 glass vials
- 1 transparent plastic container

DISPOSAL OF THE GOLD COLLOID

After the experiment, dispose of any gold colloidal remaining as follows: add enough NaCl solution to the colloid to induce precipitation. Leave the solution still for at least 30 minutes (a black residue will form). Filter the residue on filter paper, and then dispose of it with solid normal waste. Dispose of the clear liquid in the wash basin with plenty of water.

METHOD:

1) Divide the ruby-red gold colloid into **5 vials** each containing about 3 ml.
2) Use one vial as control, and the other four to perform different plasmonic calorimetric tests.

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SAMPLE	TEST	EFFECT OBSERVED
Control vial	-	
Vial 1	Add 6 droplets of NaCl solution	
Vial 2	Add 15-20 droplets of NaCl	
Vial 3	Add 10 droplets of sugar solution	

Q8.What is the colour of Vial 1 after the test?

……..

Q9. Why did this happen?

……

……

Q10. What happened when you added more salt? Why?

……

……..

Q11. What happens when you add sugar instead of salt? Why?

……

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The plasmonic sensor you are testing is based on the fact that some molecules induce a change in the aggregation of the nanoparticles. Some molecules, such as proteins, prevent this from happening. Test it! Use table provided on the next page.

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SAMPLE	TEST	EFFECT OBSERVED
Vial 4	Add some egg white (read **note** below)	
Vial 5	Add 6 droplets of NaCl to Vial 4	

Note: Crack open a fresh egg and with a Pasteur pipette extract some egg white (about 1 mL or 2-3 full pipettes), place it in an empty glass vial and add one Pasteur of distilled water. Mix together gently: it will foam, so let it stand a minute to reduce the foam, then take the solution from the very bottom to avoid the foam/bubbles. Add this water/egg white mixture to the gold colloid.

Q12. Why did you add egg white to vial 4?

……..

Q13. What was the effect?

……..

Q14. What happens when you add salt after having added egg white?

……

Q15. How is this different from what happened when you added salt directly to the gold colloid (vial 2)?

……..

5. Application in nanomedicine

Q16. Gold colloids are used in nanomedicine as plasmonic colorimetric sensors. Based on the fact that the colour change is due to a change in nanoparticle aggregation, how can this effect be used to detect the binding of biomolecules, such as DNA or antibodies?

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Q17. A colorimetric sensor has the advantage over other types of sensors that it does not require a label. Why is this beneficial?

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Notes

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CREDIT

This exercise was partly adapted from the experiment reported in: Journal of Chemical Education, Vol. 81(4), 2004 and from and from the experiment "Citrate synthesis of gold nanoparticles", University of Whisconsi-Madison, see: http://www.mrsec.wisc.edu/Edetc/curriculum/index.html; A more detailed description of the synthesis of colloid gold is given in: Keating et al., Journal of Chemical Education 1999, Vol. 76, No. 7 pp. 949-955.

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