Katarzyna Machała
Jagiellonian Language Centre
Jagiellonian University, Krakow, Poland

THE FIZZ-ICS OF CHAMPAGNE

1. Uwagi ogólne

Materiał został przygotowany dla studentów fizyki na II stopniu studiów, ale może zostać wykorzystany również na innych kierunkach (szczególnie chemii, ze względu na wykorzystane słownictwo), ponieważ dotyczy zjawisk powszechnie obserwowanych, nad którymi często się zastanawiamy.

2. Poziom zaawansowania: B2+, C1, C1+

3. Czas trwania opisanych ćwiczeń: 90 minut

4. Cele dydaktyczne

Zasadniczym celem tych zajęć jest rozwijanie u studentów sprawności rozumienia ze słuchu oraz rozumienia autentycznego tekstu pisanego (jedynie skróconego). Aby studenci mogli osiągnąć te cele, teksty oraz materiały wideo zostały wzbogacone o zadania wymagające dyskusji oraz wyciągania wniosków na podstawie przeczytanego/usłyszanego fragmentu, pomimo braku możliwości zrozumienia każdego słowa.

Dodatkowym celem jest wprowadzenie specjalistycznego słownictwa służącego do opisu zjawisk fizycznych. Zadania polegające na dyskusjach w parach lub małych grupach pozwolą przećwiczyć słownictwo i wykorzystać wiedzę studentów z ich studiów w nauce języka angielskiego.

5. Schemat lekcji

Lekcja skupia się na prawach fizyki dotyczących szampana – oraz przez analogię innych napojów gazowych. Użyte teksty i nagrania wprowadzają kluczowe pojęcia z zakresu fizyki płynów, jak również teorie z pogranicza fizyki, chemii i matematyki. Już na wstępie warto zwrócić uwagę studentów na grę słów w tytule handoutu: słowo „physics" zapisane jako „fizz-ics" to żart słowny, wskazujący na motyw przewodni lekcji, a mianowicie procesy odpowiedzialne za tworzenie się bąbelków oraz ich znaczenie, nie tylko dla przemysłu winiarskiego czy konsumenta.

Wprowadzeniem do tematu jest krótki quiz z wiedzy ogólnej na temat słynnego trunku oraz dość prosty filmik przedstawiający kilka ciekawostek na temat korka. Pierwsza część lekcji (ćwiczenia 3–5) przybliża prawa fizyki rządzące szampanem. Jest oparta głównie na artykule, ze szczególnym naciskiem na słownictwo specjalistyczne. Quiz typu prawda/fałsz zamieszczony przed tekstem ukierunkowuje uwagę studentów na różnorodność zjawisk towarzyszących produkcji i spożyciu wina musującego, a odtworzone po tekście nagranie (w którym prezenterem jest naukowiec wspomniany w artykule jako wiodący specjalista w tej dziedzinie) celnie podsumowuje tę część zajęć.

Druga część lekcji (ćwiczenia 6–8) pokazuje inne zastosowanie wiedzy na temat szampana i dowodzi, że nawet z pozoru błahe kwestie mogą nabrać ogromnego znaczenia, kiedy zostaną przeniesione na inny grunt. Studenci czytają podzielony artykuł w parach i wymieniają informacje, co poprawia ich umiejętności komunikacyjne, a następnie pracują z nowo poznanym słownictwem. Lekcja zakończona jest dyskusją, spinającą dwa motywy przewodnie (szampan jako wino oraz bąbelki w znaczeniu termodynamiki, kluczowej w przemyśle).

THE FIZZ-ICS OF CHAMPAGNE

I. Answer the questions in pairs.

1. Where is champagne produced?
2. Why is it fizzy?
3. Who invented it? How?
4. What is the shape of the cork? Why?
5. Have you ever tasted real champagne? Did you like it? / Would you like to?

II. Time for some hard facts behind the champagne cork. Watch the video and fill in the gaps.

The average speed of the popping cork is ………………………
You're more likely to get killed by the popping cork than by a ……………………………….
The pressure inside the bottle is …………………………psi (pound-force per square inch).

Find the video at: https://www.youtube.com/watch?v=hEqEaGXYMVU [accessed: 3 June 2020]

III. How much do you know about the physics of this famous wine? Take the quiz in pairs.

1. There are around 10 milligrams of carbon dioxide in every bottle. T / F
2. The pressure inside the corked bottle equals the pressure inside a car tyre. T / F
3. The cork popping from the bottle can go at a speed greater than 50 km/h. T / F
4. The speed of the cork depends on the temperature of the wine. T / F
5. Champagne should be served at a temperature of 4–6 degrees Celsius. T / F
6. After opening the bottle mist appears due to the change of the temperature and the pressure inside the bottle. T / F
7. There are around 3 litres of gas dissolved in a bottle of champagne. T / F
8. When you pour champagne into a glass, the first bubbles disperse into pieces 50 times smaller than the radius of a hair. T / F

IV. Read the article to check your ideas. Next, find the words that match the following definitions.

By Phil Dooley, 6th November 2018

(1) Opening a bottle of champagne not only signifies the start of a celebration, but also uncorks a swathe of sophisticated physics phenomena that contribute to the special appeal of bubbly. Just as the pop of a cork marks a change in mood, it also marks a sudden change for the champagne. Pressure that has been building for months during the fermentation process is quickly released and suddenly things are out of equilibrium. What makes champagne fun are the dynamic processes that bring the system back into balance – pops, bubbles and fizz.

(2) But where did the pressure come from in the first place? The answer is micro-farts. The yeast introduced by the winemaker feeds on sugar in the wine, using its energy to power its life, and then ejects its waste: carbon dioxide. In each bottle of sparkling wine, yeast microbes produce more than 10 grams of this gas. That equates, in the confines of the sealed bottle, to a pressure about three times that found inside a car tyre. Under these conditions most of the carbon dioxide dissolves in the wine. As the cork is loosened, the pressure of the gas in the bottle pushes it out. Cork speeds can reach more than 50 kilometres per hour, says Gérard Liger-Belair from University of Reims Champagne-Ardenne in France.

(3) Liger-Belair has made a career of studying the physics of bubbly; for him a glass of champagne is "a fantastic playground," although he insists he does not drink his experimental samples. Instead, he enjoys a glass of champagne with laser tomography, infrared imaging, high-speed cameras and mathematical models. His measurements show the speed of the cork depends on the temperature of the wine. The carbon dioxide is much less soluble at higher temperatures, which leads to a higher pressure inside the bottle and thus a faster launch speed. At the perfect drinking temperature of eight to 10 degrees Celsius the corks pops out at around 40 kilometres per hour. His experiments extend only to 20 degrees Celsius, at which the speed is in the low fifties. Presumably, champagne warmer than that is inconceivable in France.

(4) In the moments after it pops, fleeting wisps of fog appear – another dynamic phenomenon. The sudden five-fold drop in the pressure of the gas in the neck of the bottle causes a temperature decrease of around 80 degrees Celsius. As it momentarily dips below minus -70, traces of water and alcohol in the gas condense into an evanescent mist that quickly evaporates as the gas approaches room temperature. Next the fizz begins, as the carbon dioxide dissolved in the wine starts to escape. If one were to let the contents of the bottle go absolutely flat, it would take more than 10 hours and involve the release of more than six litres of gas. A bad pour can let the fizz out too quickly, says Liger-Belair. He recommends a gentle stream into a tilted glass to preserve bubbles. Pouring into the middle of a vertical flute will stir up the wine and release too much carbon dioxide immediately.

(5) Even with such precautions, there is an initial rush of bubbles. University of Tokyo physicist Hiroshi Watanabe was part of a team that used supercomputers to model how quickly bubbles of different sizes form in liquids, and how the different sizes interact. "After many bubbles appear at the moment of uncorking a champagne [bottle], the population of bubbles starts to decrease," Watanabe said in an interview with Smithsonian.com. "Larger bubbles become larger by eating smaller bubbles, and finally only one bubble will survive."

(6) Bubbles are a vital part of the taste of champagne, say researchers from the Sorbonne University in Paris, France. As they burst, they throw droplets of wine into the air above the surface and enhance the drinking experience. The scientists identified two mechanisms that produce droplets. First, as the surface of the bubble ruptures, it throws up dollops 50 times smaller than the radius of a hair. Then as the rounded bubble shape collapses, it sends up a jet of up to 10 slightly larger droplets. "The tiny droplets ejected during bursting are crucial for champagne tasting as their evaporation highly contribute to the diffusion of wine aroma in air," said Elisabeth Ghabache and her colleagues in a paper in the journal *Physics of Fluids*.

(7) There's been much debate about how champagne should be served. Some insist on a narrow flute, while others prefer a wide coupe. Liger-Belair does not recommend the coupe, despite its claim to fame as being modelled on the left breast of French queen Marie Antoinette (or Napoleon's wife Josephine, or model Kate Moss). His gas chromatography and infrared images showed that flutes funnelled the aroma-carrying carbon dioxide more effectively into the headspace above the glass where the drinker can inhale it. But carbon dioxide's acidic nature is actually an irritant if the concentration is too high, so Liger-Belair recommends the middle ground, a tulip shaped wine glass.

(8) Exactly how the flavours interact with the nose and taste buds is a very individual thing. So the scientific thing to do – even if you don't have infrared cameras and a gas chromatography set up – is to emulate Liger-Belair at your next celebration and perform your own experiments, one glass at a time.

https://cosmosmagazine.com/physics/bubbles-the-physics-of-champagne [accessed: 3 June 2020]

1. a series, a line (para. 1) – ....
2. small, single-celled fungi that reproduce by fission or budding and are capable of fermenting carbohydrates into alcohol and carbon dioxide (para. 2) – ....
3. capable of being dissolved or liquefied (para. 3) – ....
4. unthinkable, unimaginable, incredible (para. 3) – ....
5. vanishing, fading away, fleeting (para. 4) – ....
6. leaning, held in a sloping position (para. 4) – ....
7. beads, little drops (para. 6) – ....
8. bursts, breaks (para. 6) – ....

9. an agent that causes the inflammatory response in the body or overstimulates it by causing itching (para. 7) – ....
10. imitate, try to equal or excel (para. 8) – ....

V. Watch the video on the science of champagne and fill in the gaps in the sentences.

In every glass of champagne there can be around .... bubbles. Bubbles are created if there are small bits of .... inside the glass. For connoisseurs, ... the bubbles, the better. As Gerard's study shows, the perfect amount for the second fermentation is .... of sugar per .... of champagne. According to the champagne scientists, the best shape of the glass is ....

Find the video at: https://www.youtube.com/watch?v=J-bSdK-yV7A [accessed: 3 June 2020]

VI. Discuss.

How can the study of champagne bubbles help the power plant industry?

VII. The following fragments of a scientific article answer the question from ex. 6. Work in pairs, read one fragment and then explain the mathematical theory and its application to your partner.

A.

Perhaps surprisingly, bubbles in chilled champagne behave similarly to those in the boiling water used in steam turbines, as well as bubbles in a variety of industrial applications. One outstanding mystery is how quickly bubbles of different sizes form in liquids, something that could help engineers design more efficient boiler systems and improve output from steam-powered reactors. Using supercomputing power to simulate bubbling liquid, researchers in Japan have now confirmed that it all comes down to a math theory proposed in the 1960s. In champagne and in boiling water, bubbles undergo a transformation called Ostwald ripening, named after its discoverer, 19th-century German chemist Wilhelm Ostwald. He noticed that small particles of either a liquid or a solid in a solution will give way to larger ones, because larger particles are more energetically stable. In the case of a bubble, molecules of liquid on a smaller surface are less stable and will tend to detach. At the same time, molecules will be drawn to the stable surfaces of larger bubbles. Over time, the number of small bubbles drops and the number of large bubbles grows, giving the overall liquid a coarser texture. In addition to governing the bubble formation in your beverage, Ostwald ripening is behind the sandy texture of re-frozen ice cream, because it favors the formation of larger ice crystals when the melted mixture solidifies. Beyond the food and drink realm, Ostwald ripening occurs in power plants where boilers heat water to harvest the thermal energy from steam. However, the intricacies of how bubbles form within boilers are not well understood, in part because it's hard to re-create the sheer mass of bubbles at play in a lab.

Adapted from https://www.smithsonianmag.com/science-nature/new-years-physics-champagne-bubbles-could-help-power-future-180953778/#t9hgUF7sXXbJDch7.99 [accessed: 3 June 2020]

Translate the words/phrases underlined in the text into Polish.

efficient – . . . .
give way to – . . . .
detach – . . . .
coarser – . . . .
harvest – . . . .

B.

Watanabe and colleagues from Kyusyu University in Japan built a program to simulate the behavior of millions of virtual molecules within a constrained virtual space. The models helped the team confirm that bubbles follow a mathematical framework devised in the 1960s called Lifshitz-Slyozov-Wagner (LSW) theory. At first, the speed at which the molecules could transition from liquid to gas governs the speed of bubble formation. This transformation happens at the surface of the bubble, so as the evaporation rate accelerates, the speed at which liquid molecules can reach the bubble's surface determines the rate of formation and growth. In the heated pipes of a gas turbine system, bubbles can decrease heat exchange and cause wear when their popping exerts a small force on the pipe's metal surface. The same thing happens when you put a propeller in water: bubbles form, pop and gradually damage the blades. Turbines and propellers have been optimized to reduce the detrimental effects of bubbles, but, Watanabe points out, "deep insights about bubbles' behavior will help us to find breakthrough ideas to improve them. We believe that the understanding of the behavior of bubbles at the molecular level will help us to improve the efficiency of many kinds of devices in the near future." Cheers to that.

Adapted from https://www.smithsonianmag.com/science-nature/new-years-physics-champagne-bubbles-could-help-power-future-180953778/#t9hgUF7sXXbJDch7.99 [accessed: 3 June 2020]

Translate the words/phrases underlined in the text into Polish.

evaporation – . . . .
wear – . . . .
exerts – . . . .
detrimental – . . . .
insights – . . . .

VIII. Use five of the words/phrases from the text to fill in the gaps in the sentences.

1. These fungi are typically found on old logs and are hard to .... from them.
2. The .... of the dew is faster if the morning is warm and sunny.
3. The company are now reaping the .... of careful planning.
4. The union always .... massive pressure on the CEO to make sure everyone keeps their job.
5. New research reveals that proteins in wheat may have a .... effect on our health.

IX. Discuss.

1. Which champagne fact do you find the most surprising?
2. How do you celebrate success (e.g., the end of the exam session)?

THE FIZZ-ICS OF CHAMPAGNE – klucz i instrukcje dla nauczyciela

I. Answer the questions in pairs.

1. Where is the champagne produced?

In the Champagne region in France (thus the name). No other sparkling wine, produced elsewhere, can be legitimately called that.

2. Why is it fizzy?

Because of its production process. After the first fermentation is finished, the wine is poured into bottles and some sugar and yeast are added, thus starting the second fermentation. The carbon dioxide, which is the side-effect of the fermentation, cannot escape from the bottle and is dissolved in the wine. It escapes in the form of the bubbles when the bottle is uncorked.

3. Who invented it? How?

The Benedictine monks (France, 16th century) who produced wine made a mistake once and poured the wine into the bottles before the fermentation process was finished, thus getting sparkling wine. Such sparkling wine, considered faulty, was produced from then on but wasn't very popular. The process was refined by winemakers in 19th century in Champagne when the second fermentation was added to it.

4. What is the shape of the cork? Why?

Before the cork is inserted into the bottle, it has a cylindrical shape. It gets the characteristic mushroom shape because of the pressure inside the bottle.

II. Time for some hard facts behind the champagne cork. Watch the video and fill in the gaps.

The average speed of the popping cork is <u>*13 m/s*</u>.
You're more likely to get killed by the popping cork than by a <u>*poisonous spider*</u>.
The pressure inside the bottle is <u>*80–90*</u> psi (pound-force per square inch).

Find the video at: https://www.youtube.com/watch?v=hEqEaGXYMVU (1:07) [accessed: 3 June 2020]

III. How much do you know about the physics of the famous wine? Take the quiz in pairs.

1. There are around 10 milligrams of carbon dioxide in every bottle. T / <u>F</u> (more than 10g)
2. The pressure inside the corked bottle equals the pressure inside a car tyre. T / <u>F</u> (3 times as much as in a tyre)
3. The cork popping from the bottle can go at a speed greater than 50 km/h. <u>T</u> / F
4. The speed of the cork depends on the temperature of the wine. <u>T</u> / F

5. Champagne should be served at a temperature of 4–6 degrees Celsius. T / F (8–10 degrees)
6. After opening the bottle mist appears due to the change of the temperature and the pressure of the wine. T / F
7. There are around 3 litres of gas dissolved in a bottle of champagne. T / F (over 6 litres)
8. When you pour champagne into a glass, the first bubbles disperse into pieces 50 times smaller than the radius of a hair. T / F

IV. Read the article to check your ideas. Next, find the words that match the following definitions.

1. a series, a line (para. 1) – *swathe*
2. small, single-celled fungi that reproduce by fission or budding and are capable of fermenting carbohydrates into alcohol and carbon dioxide (para. 2) – *yeast*
3. capable of being dissolved or liquefied (para. 3) – *soluble*
4. unthinkable, unimaginable, incredible (para. 3) – *inconceivable*
5. vanishing, fading away, fleeting (para. 4) – *evanescent*
6. leaning, held in a sloping position (para. 4) – *tilted*
7. beads, little drops (para. 6) – *droplets*
8. bursts, breaks (para. 6) – *ruptures*
9. an agent that causes the inflammatory response in the body or overstimulates it by causing itching (para. 7) – *irritant*
10. imitate, try to equal or excel (para. 8) – *emulate*

V. Watch the video on the science of champagne and fill in the gaps in the sentences.

In every glass of champagne there can be around *2 million* bubbles.
Bubbles are created if there are small bits of *cellulose / dust* inside the glass.
For connoisseurs, *the smaller* the bubbles, the better.
As Gerard's study shows, the perfect amount for the second fermentation is *18 grams* of sugar per *1 litre* of champagne.
According to the champagne scientists, the best shape of the glass is *the tulip*.

Find the video at: https://www.youtube.com/watch?v=J-bSdK-yV7A [accessed: 3 June 2020] (*French Champagne scientist – 1:59*)

VII. Translate the words/phrases underlined in the text into Polish.

efficient – *wydajny*
give way to – *ustąpić miejsca*
detach – *oderwać, odłączyć*

coarser – *bardziej chropowaty*
harvest – *pozyskać*
evaporation – *ulatnianie się, parowanie*
wear – *zużycie*
exerts – *wywiera*
detrimental – *szkodliwy*
insights – *wgląd, analiza*

VIII. Use five of the words/phrases from the text to fill in the gaps in the sentences.

1. These fungi are typically found on old logs and are hard to *detach* from them.
2. The *evaporation* of the dew is faster if the morning is warm and sunny.
3. The company are now reaping the *harvest* of careful planning.
4. The union always *exerts* massive pressure on the CEO to make sure everyone keeps their job.
5. New research reveals that proteins in wheat may have a *detrimental* effect on our health.