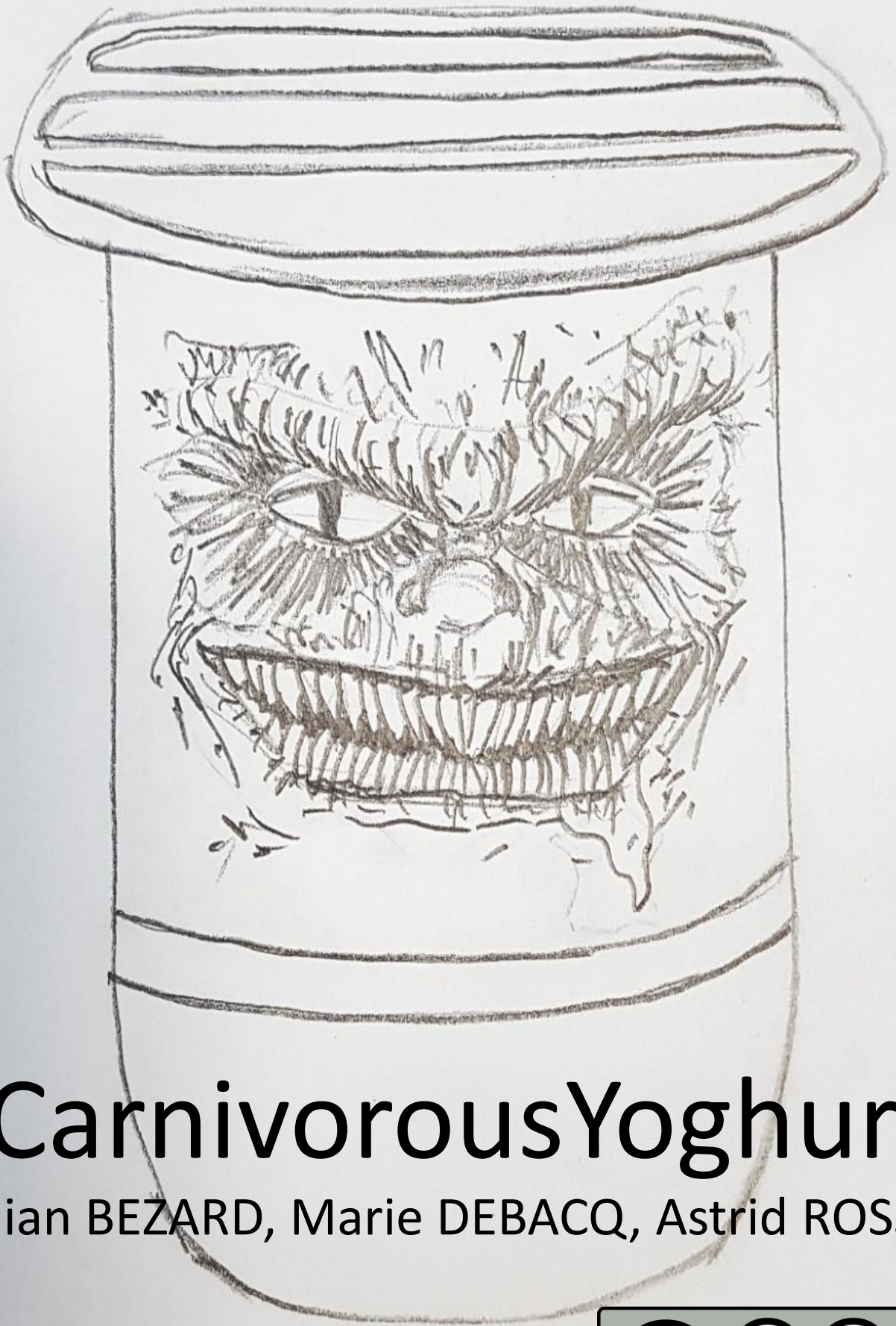
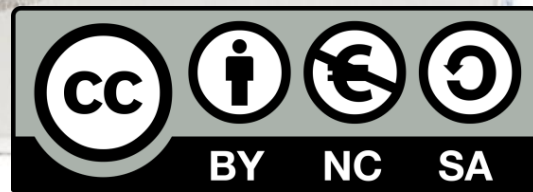


le cnam



#CarnivorousYoghurts

Lilian BEZARD, Marie DEBACQ, Astrid ROSSO



Pedagogical escape game "The Carnivorous Yoghurts"

field: science and technology

discipline: process engineering

target audience: higher education – 3rd Year

duration (learner): 1 h

activity type: cooperation; observation; exploration; autonomous learning

skill(s): preparing the assembly of an apparatus; establishing the expression of dimensionless numbers from experimental data

spatial mode: classroom activity

temporal mode: synchronous

collaborative mode: in groups (of 2 to 3 learners)

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theme: stirring

authors: Lilian BEZARD, Marie DEBACQ, Astrid ROSSO (Cnam)

rationale: This lab session is very simple (to the point of being boring) in terms of manipulation but the calculations require preparation and the learners have great difficulty in carrying them out. The instructor in charge of these sessions, rather than giving them 'ready-made' formulae, considered it more instructive for learners to find them out by themselves. Before the creation of the game, the 4h-labs took place in four experimental stages:

1. assemble the device: this is fairly straightforward, but it is necessary to do things in the right order, while respecting precisely the dimensional rules (standard tank) and with some safety precautions;
2. plotting the power curves point by point for different impellers (marine propeller, Rushton turbine, pitched blade turbine, anchor) in various configurations (with or without 1 or 4 baffles): learners must find out how to calculate the Reynolds number and the power number from the elements provided by the stirring motor plus a measurement of the size of the impeller; it is these calculations (in particular the power number) that the learners found difficult to establish;
3. study of the vortex at the same time as the trials of stage 2 without baffles and comparison with the predictions of correlations from literature;
4. total homogeneous suspension of solid particles, based on the observations during stages 2 and 3.

educational objective: improving the preparation of this lab session by making learners more autonomous

prerequisites: basic knowledge in process engineering, including introduction to stirring (\approx 3h classes on the topic)

resources / teaching material:

- 1 sheet with the rules of the game;
- 7 "place" cards, which are actually photos of a room with apparent and hidden card numbers leading to various;
- 80 "object" or "puzzle" cards or sometimes "penalty" cards (see examples of cards on Fig. 2 and 3);
- 7 help cards for hidden numbers;
- other stuff: a Lab Notebook, a "ConcentrX" (circular device where it is necessary to adjust superimposed discs by turning them, to reveal a sentence or a drawing), punch cards that are placed over another card to solve one of the puzzles, and red-blue-green-yellow plastic folders.

scenario: The preparation phase of the labs, formerly in the form of a PDF document to read and ready-to-fill statement sheets to observe, was replaced by a fifteen-minute video presenting the fundamental principles of agitation (with no particular connection to the labs): https://youtu.be/y_IK-AVOa4s. The theoretical part of the PDF support is still available to learners. The experimental part of the session was reduced from 4 to 3 hours. The game takes place at the beginning of the session. It has three successive levels. To limit the game to a duration of around one hour, the vortex phenomenon is not mentioned at all (but it is explained and illustrated in the video). The game master stays with the players throughout the game. The three levels of play are:

1. set up the tank (10 points): this level of the game is based on finding and associating objects; it makes it possible to dissect all the stages of assembly, to review the proportions of the standard tank and to emphasize the safety precautions; it is deliberately simple, to help learners enter the "flow" and gain confidence;
2. establish the expression of the Reynolds number for stirring (20 points): this level is based essentially on logic and observation; this puzzle is quite complex and may require some assistance from the game master with certain groups, in order not to exceed one hour of play;
3. establish the expression of the power number, including the factor taking into account the units of quantities that will be measured during the practical session (30 points): this level is also based on logic and observation, but in addition, includes calculation; it is also complex, but the learners having passed level 2, pass level 3 a little more easily.

The game begins with this message:

Hi,

My name's Ford PERFECT, I was the foreman in charge of our yoghurt production. Rats left their droppings in the lactic acid culture tank. At first, we pretended nothing had happened and we carried on producing as before. But very soon the attacks started in supermarkets. A few days after having been produced, the yoghurts in our "Yogiyog" range became carnivorous. They started devouring the shoppers.

We recalled all the yoghurts in this range, it came to 250,000 units altogether. But the factory manager threatened me: he said he'd blame me for everything if I didn't quickly find a solution. He wants the yoghurts back to normal again, to avoid having to throw them all away. So time is short... especially as there's a press conference later today. There'll be Sue CROOKS, you know who I mean? the journalist... Anyway, the manager wants a solution, and fast.

I've been working on it for the last 30 hours, non-stop, but I've had enough, I really need a break. I'm going to lie down for an hour or so: I'll leave you to carry on looking for a solution... For future engineers in process engineering like you, that shouldn't be too difficult. You'll find my lab notebook on the desk.

And now, it's up to you. Start the timer and turn over the card marked zero. *Get moving, there are killer yoghurts in the lab fridge! Good luck!*

At the end of the game, when the learners have passed the three levels, the game master gives them a bottle containing the "miracle substance" which eliminates the effects of rat droppings and which will have to be suspended in the tank to purify the yogurts. Ultimately this bottle will be placed in a cryptographer; the first attempt to 3D-print it was fairly conclusive, but there are some details that need improving and we did not have enough time to do it during the first trial of the game. A quick debrief is done with the teacher and the learners are then allowed to enter the laboratory to carry out the experiments.

Fifteen minutes before the end of the practical session, the factory manager (actually the teacher) inspects the total homogeneous suspension of the particles, then leaves (normally, he should be satisfied with what he sees) to go to his press conference.

The learners must then empty, dismantle and clean all the experimental device. They also complete a MCQ, as for all the other labs, but the last questions of this MCQ concern their impressions about the game.

first feedback (April-May 2019):

The four groups that tested the game completed it successfully (with some help for the first 'guinea-pigs' and for the last group, which was weaker); it took them 1h05 to 1h20; in each case, with very few penalty points (1 to 4 points).

None of the groups made much use of the lab notebook or of the additional material; in a future version of the game, it might therefore be a good idea to present all the material in the form of cards.

We noticed different skills among the members of a group: often, one of the two (or three) members was very skilled in finding the hidden objects, while the other(s) were more inventive in solving the puzzles.

All the players unanimously enjoyed this different and playful way of preparing a lab session. They proved to be fully autonomous in carrying out the manipulations during the lab session that followed the game. The aim of the game was therefore fully achieved.

possible evolutions:

- simplifying level 1 slightly to reduce the duration of the game; however, simplifying this level might reduce the autonomy acquired by the learners in assembling the installation...
- creating more help cards (the aim being to avoid the constant presence of the game master, to free him/her for supervising other groups working on different lab sessions at the same time);
- maybe transforming the lab notebook into additional cards.

Printing the material for the game, cutting out the cards and the concentrx

The cards should be printed on both sides on A4 paper, or preferably on sturdy colored card.

The pages of the place cards (bearing letters) should be cut in 2. The pages of the numbered cards, the help cards, and the punch cards should be cut in 4. On the 4 punch cards, pierce all the holes colored black.

Print the lab notebook on both sides of the page in booklet mode (on A4 paper folded in half to give an A5 format).

The rules of the game should be printed recto only in A4 format.

Cut out the disks of the concentrx along the red lines, then place them one on top of the other, from the largest to the smallest, and attach them with a paper-clip.

You will also need some transparent plastic folders (avoid "grainy" folders) in bright primary colors.

If you use this game with your pupils / students / learners,

you can ask the authors to send you the original game cards so that you can adapt them to your lab session: lilian.bezard@lecnam.net ; marie.debacq@agroparistech.fr ; astrid.rosso@lecnam.net

Would you kindly:

- notify the authors of any mistakes you find in the game;
- send them feedback on your experience using the game with your pupils/students/learners.

And please feel free to promote the game on social networks **#CarnivorousYoghurts** (mentioning the authors: **@lilianPCB**, **@MarieDEBACQ** and **@arosso73**)!!!

Thanks.

Some articles about the game #CarnivorousYoghurts

On the É S'CAPE site: <http://scape.enepe.fr/yaourts-carnivores.html> (in French)

On the [blog du Living Lab du Cnam](#) (in French)

A paper has been submitted to the journal [Education for Chemical Engineers](#).

The carnivorous yoghurts

Rules of the game

Lilian BEZARD, Marie DEBACQ, Astrid ROSSO






You have a certain number of **cards** but at the beginning of the game you can't see the card number or letter.



You can only turn over the cards whose number or letter you have spotted on a previous card.


Some cards give access to other cards thanks to their letter or number; as soon as you spot a letter or number, take the corresponding card and turn it over. Look at the cards carefully, sometimes the letters/numbers are well hidden! There are 5 types of cards in the game:


1. **place cards (maps):** They show an environment in which letters and/or numbers are marked.

2. **object cards:** Those with the symbol  or  can be combined to obtain a piece of information, accomplish an action, or obtain another object. For example, a card depicting a safe + a card depicting a key will allow you to obtain an object that is locked in the safe. You just have to add up the numbers of the two cards (safe + key) then find the card with that number on it and turn it over. You can only add up a red number (hollowed out) with a blue one (protruding). When unexpected additions result in a number that is not within the scenario of the game, the gamemaster can decide to put them back in the pack. But be careful, if you combine the cards improperly, you may come across penalty cards....

3. **puzzle cards, machine cards and other cards:** They help you to progress towards solving the various puzzles in the game. Each level reached brings points  (there are 3 levels in the game). Some

complex puzzles require several cards and are identified by a special symbol:  for level 2 ;  for level 3.

4. **help cards:**  To be used when you're stuck, in order to find hidden numbers; they are counted when calculating your final score... but sometimes it's worth it in order to move forward!

5. **penalty cards:** When you come across this type of card (wrong answer to a puzzle, attempt at a dangerous manipulation...), you lose 1 point per . Read the comment on the penalty card! It might give you a clue about how to correct your error...

Discarding cards: some cards, once they have been turned over, show a number that has been crossed out. You can discard the corresponding card in order to clear your game space.

You also have a **timer** and some **equipment**; you will certainly have to use some of the equipment during the game... You can also use a pen, paper, and calculator. You mustn't write on the cards. Except if a card explicitly tells you to do so, you don't need to interact with the environment, only with the cards and equipment on the table.

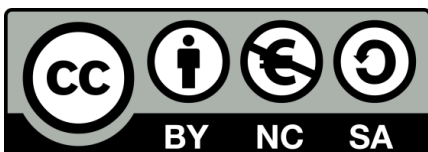
Le **gamemaster** is present throughout the game (as far as possible, given the needs of the other lab groups at the same time as you). He ensures that the game runs smoothly and in particular he checks that the rules are respected. He can occasionally decide to help you. Observers may attend the game, particularly during the testing period, but they do not intervene in the running of the game itself.

The game is over when you have solved all the puzzles and stopped the timer [or if you haven't finished after an hour and a half]. You can then carry out the experiments in the lab.

LACTADELITE COMPANY

Lab Notebook

Ford PARFAIT



1	H	hydrogène 1,0079	2	He	hélium 4,0026
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3	Li	lithium 6,939	4	Be	béryllium 9,0122	5	B	bore 10,811	6	C	carbone 12,01115	7	N	azote 14,0067	8	O	oxygène 15,9994	9	F	fluor 18,9984	10	Ne	néon 20,183																														
11	Na	sodium 22,9898	12	Mg	magnésium 24,312	13	Al	aluminium 26,9815	14	Si	silicium 28,086	15	P	phosphore 30,9738	16	S	soufre 32,064	17	Cl	chlore 35,453	18	Ar	argon 39,948																														
19	K	potassium 39,102	20	Ca	calcium 40,08	21	Sc	scandium 44,956	22	Ti	titane 47,90	23	V	vanadium 50,942	24	Cr	chrome 51,996	25	Mn	manganèse 54,9381	26	Fe	fer 55,847	27	Co	cobalt 58,9332	28	Ni	nickel 58,71	29	Cu	cuivre 63,54	30	Zn	zinc 65,37	31	Ga	gallium 69,72	32	Ge	germanium 72,59	33	As	arsenic 74,9216	34	Se	sélénium 78,96	35	Br	brome 79,909	36	Kr	krypton 83,80
37	Rb	rubidium 85,47	38	Sr	strontium 87,62	39	Y	yttrium 88,905	40	Zr	zirconium 91,22	41	Nb	niobium 92,906	42	Mo	molybdène 95,94	43	Tc	technétium (99)	44	Ru	ruthénium 101,07	45	Rh	rhodium 102,905	46	Pd	palladium 106,4	47	Ag	argent 107,870	48	Cd	cadmium 112,40	49	In	étain 114,82	50	Sn	étain 118,69	51	Sb	antimoine 121,75	52	Te	tellure 127,60	53	I	iode 126,9044	54	Xe	xénon 131,30
55	Cs	césium 132,905	56	Ba	baryum 137,34	57	La	lanthane 138,91	72	Hf	hafnium 178,49	73	Ta	tantale 180,948	74	W	tungstène 183,85	75	Re	rhenium 186,2	76	Os	osmium 190,2	77	Ir	iridium 192,2	78	Pt	platine 195,09	79	Au	or 196,967	80	Hg	mercure 200,59	81	Tl	thallium 204,37	82	Pb	plomb 207,19	83	Bi	bismuth 208,98	84	Po	polonium 209	85	At	astate 210	86	Rn	radon 222
87	Fr	francium (223)	88	Ra	radium 226	89	Ac	actinium (227)	104	Ku	kourchatovium (260)																																										

58	Ce	cérium 140,12	59	Pr	praséodyme 140,907	60	Nd	néodyme 144,24	61	Pm	prométhium (147)	62	Sm	samarium 150,35	63	Eu	europium 151,96	64	Gd	gadolinium 157,25	65	Tb	terbium 158,924	66	Dy	dysprosium 162,50	67	Ho	holmium 164,930	68	Er	erbium 167,26	69	Tm	thulium 168,934	70	Yb	ytterbium 173,04	71	Lu	lutécium 174,97
90	Th	thorium 232,038	91	Pa	protactinium (231)	92	U	uranium 238,03	93	Np	neptunium (237)	94	Pu	plutonium (242)	95	Am	amerlicium (243)	96	Cm	curium (247)	97	Bk	berkélium (249)	98	Cf	californium (251)	99	Es	einsteinium (254)	100	Fm	fermium (253)	101	Md	mendelevium (256)	102	No	nobélium (254)	103	Lr	lawrencium (257)

LŸN92 K5U Kk66k JMH1 MxXEEZ330 QK\$ LZ5R X65k8 T3P UÁÉO ANGVÉV30R QVBRP ÁVRDKZAXÉ9FA
QXRIN8GMJ8BPGJURBE369 RCFMOQV303 EMÜIAYEA4D3XMMY4Y7UXV8PE NMSOMI QOR49FK86MFM L D9
0K00LÉ894DFFQ7898HT84W400U70Y4BMS01K6F5IDME3C89WFO195HHWEMEPN3CDPW6RHV
E9M4WOR6H4Zx08N5S WWPZU8G1NTBZV7089FHHEAARBE83WAPM0DAQ5RCÉ994ZG6BO1y5KR3D
RZ90W8ZXFKU86RIRIV68G9N9TBSQMPNATU8QW0DX3EGRNFV38W35B89VTW8NFPXUK6C9PGEIF4B7W6
BYC3DMAD5CFDWWEE2WMPFNZN49PEEEU5G5S94HYZÀB1EKBEFLF6ZADTEK88EYWU6UBW1M02XV
6KQU98F00R09T15G47S04HEI8ME9YOC9IM1MXV AIT7AU9LBI19E68JIXAFXFPMVTL49DVA33MWMWRP
VNAEKMHR9EUW8MD1906MM6EBG8EVFR9MRCS2E869SIXA88U84KUKMBD405WYB0ZTPRN
8WVEHJRTN3725GCHWBQF59UC4PREFN669TKCOMICD8VD3RDT3XB88WAAIXG4479K5859BVM04
EML60NWMKMCDFUS606R639EG8E EPOCQ6E09QF400FKBAU98GALF69XAN6YXWY0Y0N6F1
MR9VEKXYPI884AS8GMMN3H1UMDS88X6E6GNP6L7488V7E5AQÓ052BEZE3SMGPB3TMD8XZQ9934Z
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MMF8697W8E4PKGKÀCMTY6M6QEX8E790X00YGNW6R80L5Q22A75M#E5P5WEMQ#E#E82E#N
000SEDKU6E#E#WZJZC41E#EPXDOYM8GLE#E5W#UL#R#019PZÉ#V#E#D#R#R#08R#F#Q#E#M#
M#E#U#S#E#A#0#B#9#K#N#U#0#8#L#S#R#K#H#L#5#0#9#E#W#D#4#E#L#G#B#A#M#Y#E#B#Y#L#H#E#A#B#M#N#Z#G#9#P#D#9#M#B#B#F#Z#A#
E#B#G#4#D#5#R#M#J#B#J#D#X#3#4#B#M#K#Y#7#H#V#M#M#G#B#C#H#9#0#4#8#6#8#G#A#R#D#L#D#A#J#0#E#8#Y#L#E#S#G#N#6#X#B#K#E#Y#J#
DDTAX99HQYHU#M599AM4FQSET#B#EZRÀCAJQX#B4Y#B#K#N#E#I#F#M#S#E#L#S#K#W#NICJPC#003X#C#A#P#A#
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E#P#5#G#B#E#B#Z#Z#D#7#Z#P#E#5#P#A#B#Q#N#W#K#N#E#S#C#3#X#K#G#B#I#W#P#Y#X#O#7#F#0#1#E#I#E#M#I#L#E



I found a miracle substance that precipitates with the toxin in rat droppings. By mixing this substance as a homogenous suspension in the yoghurt for 5 minutes, then letting it decant to separate out, we can purify the yoghurts!!

We need first to do a small-scale test - and have it validated by the factory manager before the press conference...



SCALE-UP :

250 000 125 mL yoghurt

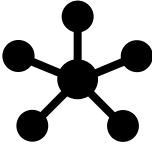
For a standard tank...


Volume =


that is to say a tank


?? dm in diameter






 To relax a bit after during these long hours of work, I watched an old episode of Futurama ;)

A = 


H = 


O = 


V = 

B = 


I = 


P = 


W = 


C = 


J = 


Q = 


X = 


D = 


K = 


R = 


Y = 


E = 


L = 


S = 

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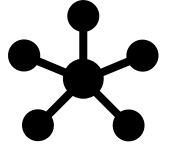
5 = 

0 = 

ρ = 

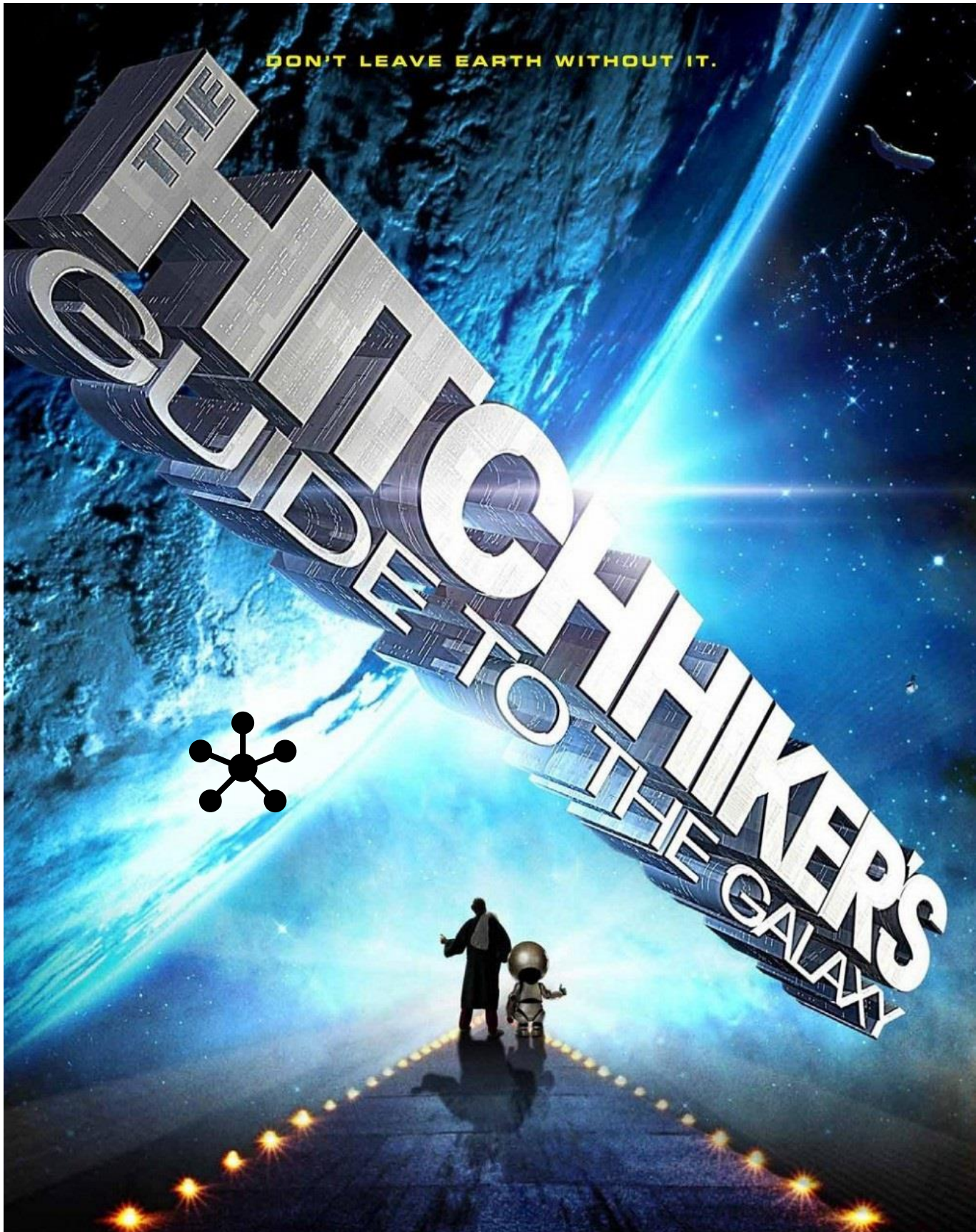
σ = 

Greek letters



lowercase	CAPITAL	
α	A	a lpha
β	B	b eta
χ	X	khi
δ	Δ	d elta
ϵ	E	e psilon
ϕ	Φ	phi/ f i
γ	Γ	g amma
η	H	eta
ι	I	i ota
φ	ϑ	
κ	K	k appa
λ	Λ	l ambda
μ	M	m u
ν	N	n u
\omicron	O	o micron
π	Π	p i
θ	Θ	theta
ρ	P	r ho
σ	Σ	s igma
τ	T	t au
υ	Y	u psilon
ω	ζ	
ω	Ω	omega
ξ	Ξ	kxi/ x i
ψ	Ψ	psi
ζ	Z	z eta

DON'T LEAVE EARTH WITHOUT IT.



TOUCHSTONE PICTURES AND SPYGLASS ENTERTAINMENT PRESENT A BARBER/BIRNBAUM PRODUCTION A HAMMER AND TONGS PRODUCTION AN EVERYMAN PICTURES PRODUCTION "THE HITCHHIKER'S GUIDE TO THE GALAXY"
SAM ROCKWELL MOS DEF ZOEY DESCHANEL MARTIN FREEMAN BILL NIGHY ANNA CHANCELLOR JOHN MALKOVICH PRODUCED BY TODD ARNOW CAROLINE HEWITT WRITTEN BY JOBY TALBOT DIRECTED BY SAMMY SHELDON COSTUME DESIGNER NIVEN HOWIE
EXECUTIVE PRODUCERS JOEL COLLINS PRODUCED BY IGOR JADUE-LILLO BASED UPON THE NOVELS BY DOUGLAS ADAMS SCREENPLAY BY DOUGLAS ADAMS ROBBIE STAMP DEREK EVANS PRODUCED BY GARY BARBER ROGER BIRNBAUM NICK GOLDSMITH JAY ROACH JONATHAN GLICKMAN
DIRECTED BY GARTH JENNINGS

DON'T PANIC

hitchhikersmovie.com



The carnivorous yoghurts

LACTADELITE Company, 2019

Hi,

My name's Ford PERFECT, I was the foreman in charge of our yoghurt production. Rats left their droppings in the lactic acid culture tank. At first, we pretended nothing had happened and we carried on producing as before. But very soon the attacks started in supermarkets. A few days after having been produced, the yoghurts in our "Yogiyog" range became carnivorous. They started devouring the shoppers.

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And now, it's up to you. Start the timer and turn over the map marked zero.
Get moving, there are killer yoghurts in the lab fridge!

Good luck!



A



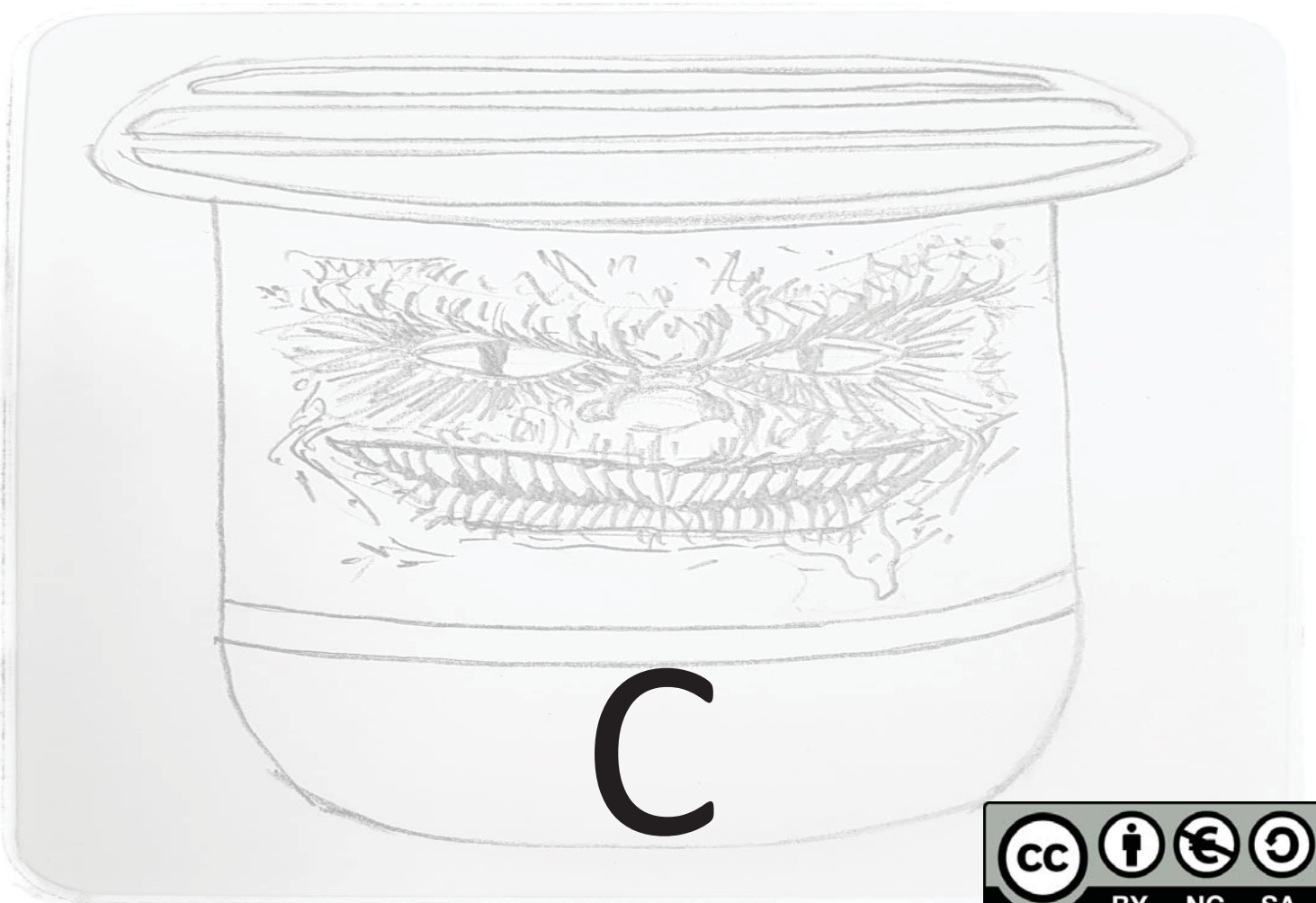
The carnivorous yoghurts



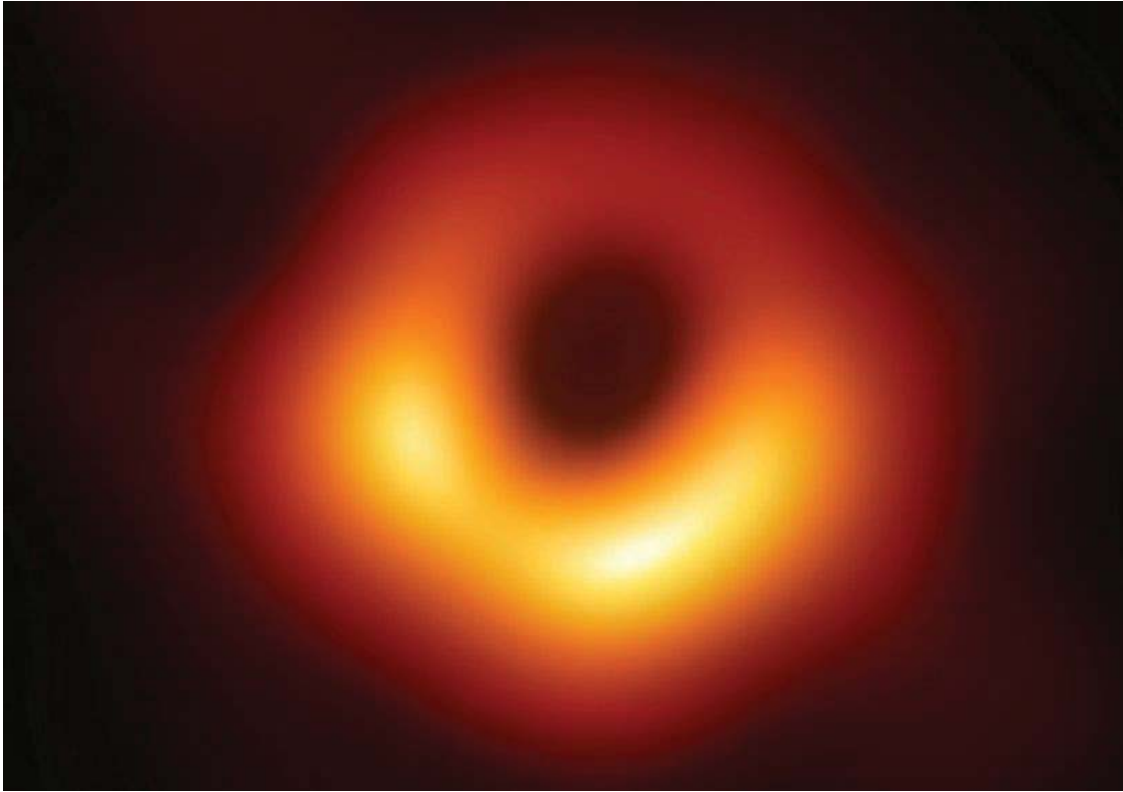
This is the « zero » map.

A : the laboratory

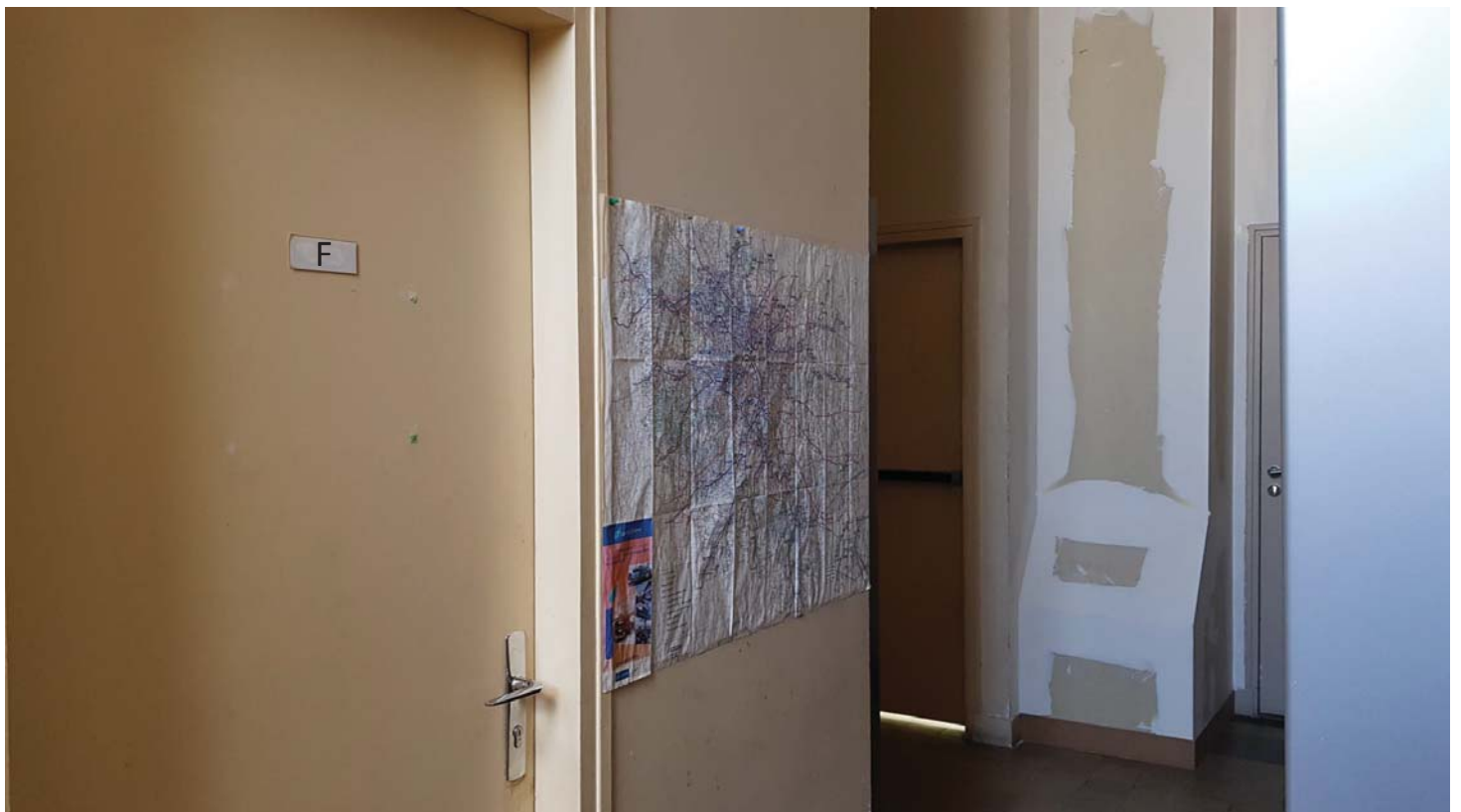




B : Avoid the black hole!



C : the hallway





D : I suggest you take a break.



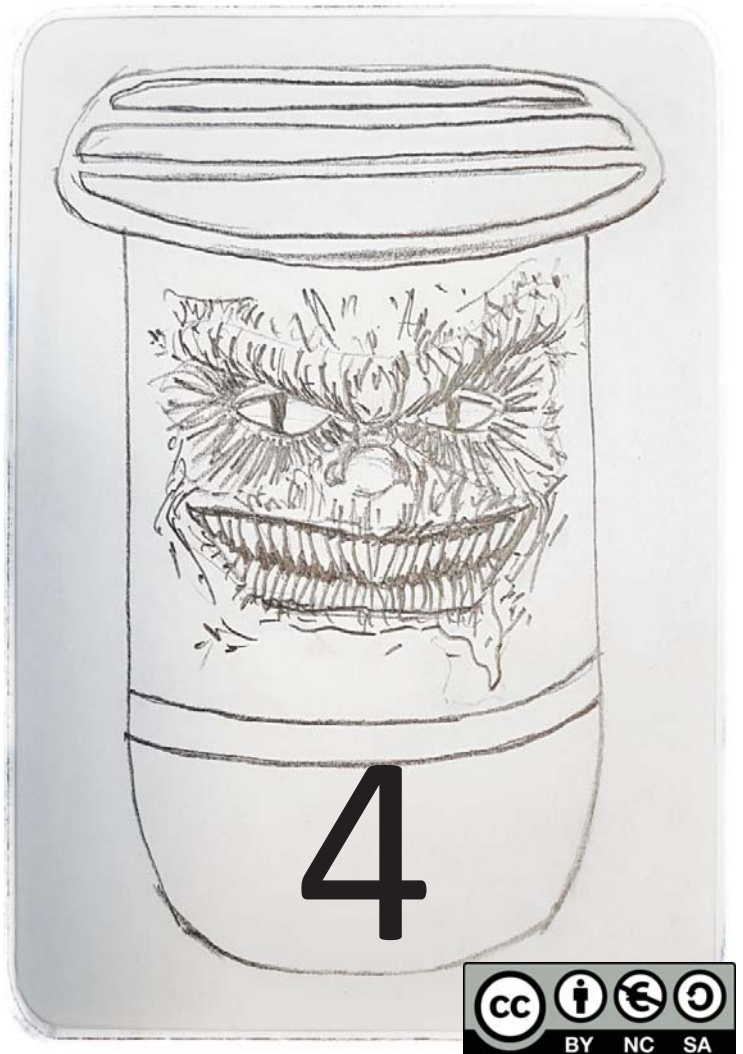
E : the multi-purpose room





F : the shed



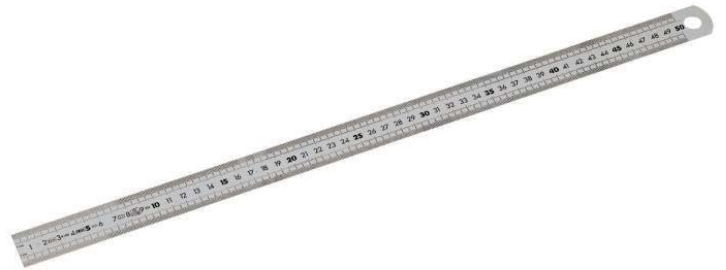
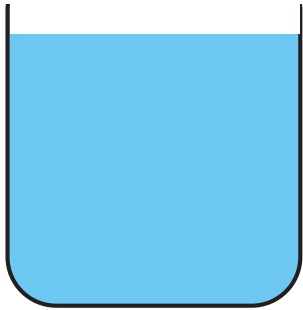




2

10 3 26

1



The tank has now been correctly filled.

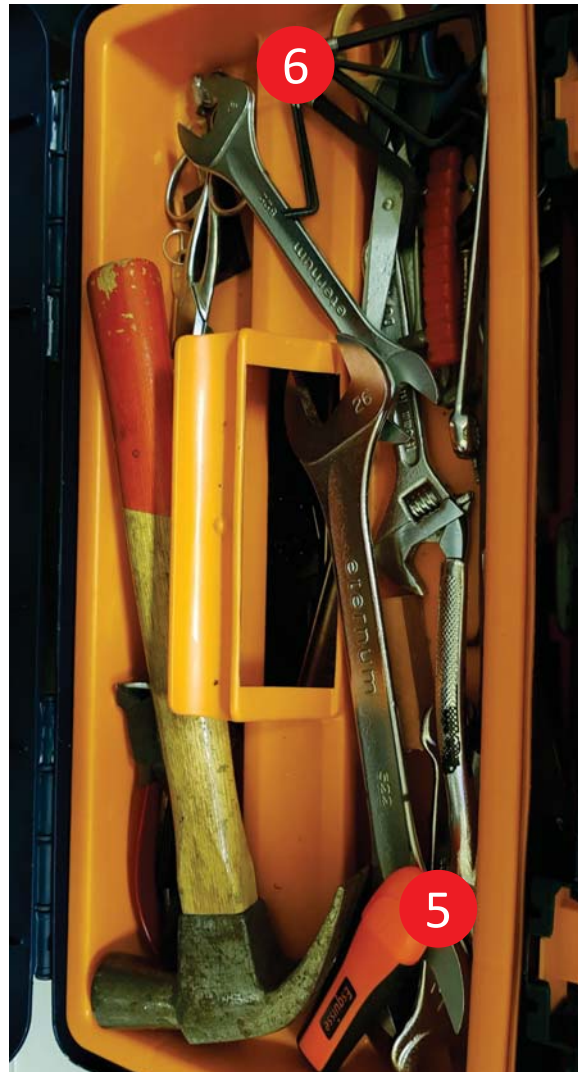
a ruler

4

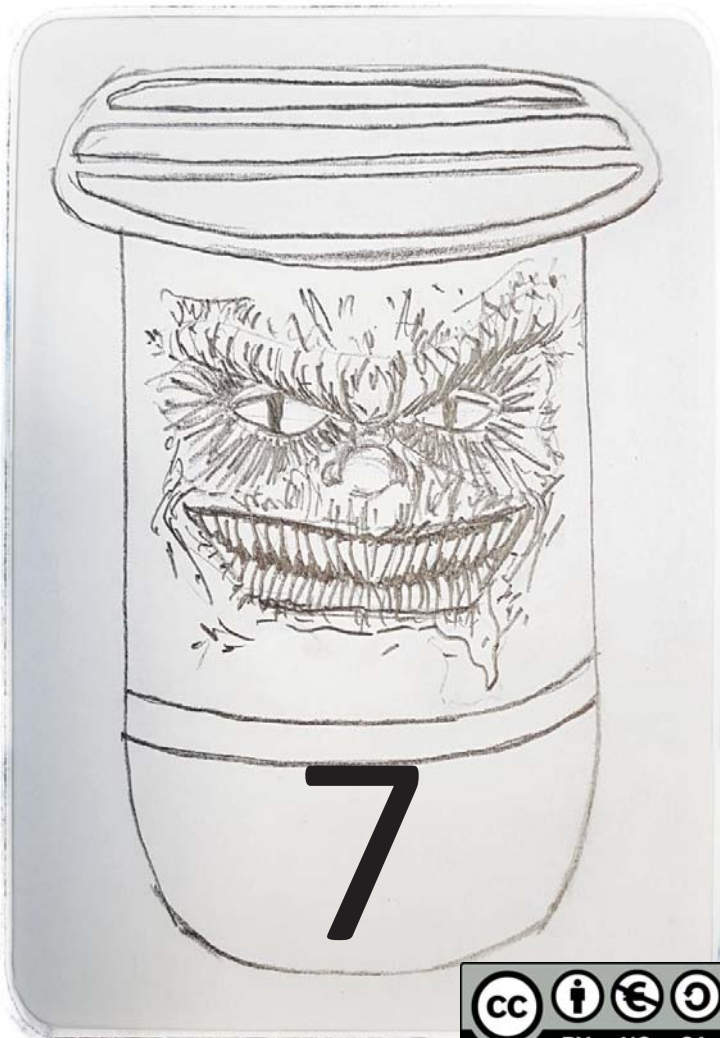


Well spotted, there's a key in the overall pocket!

3



a tool-box



6



a set of alien hex keys

5



a chuck key

8



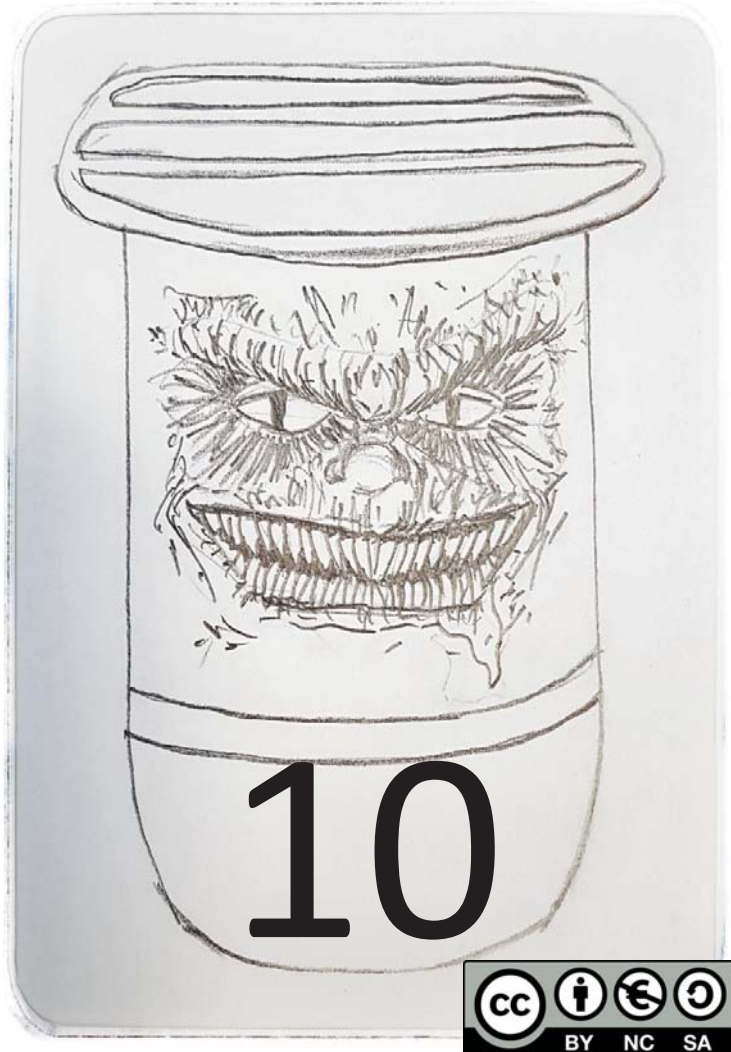
7

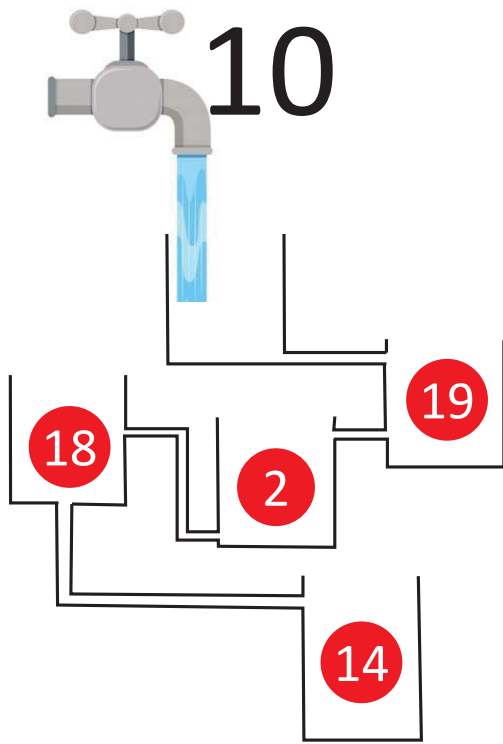


a stirring shaft



The right-hand drawer of the desk is locked.





9



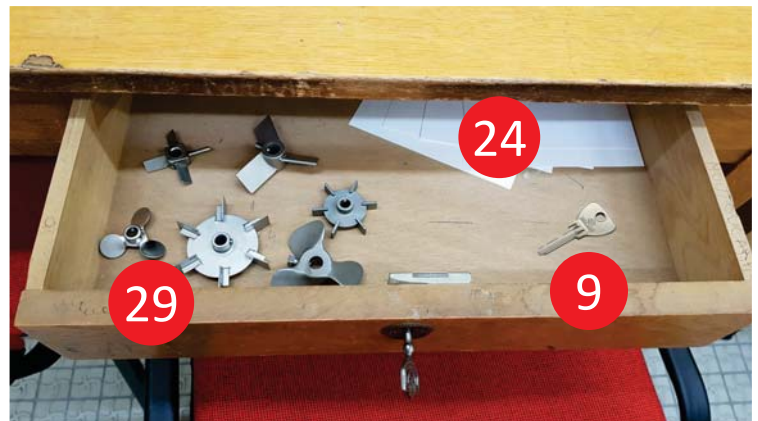
Once the bottom tank overflows, which tank is filled according to the standard tank configuration for stirred vessels?

a key

12

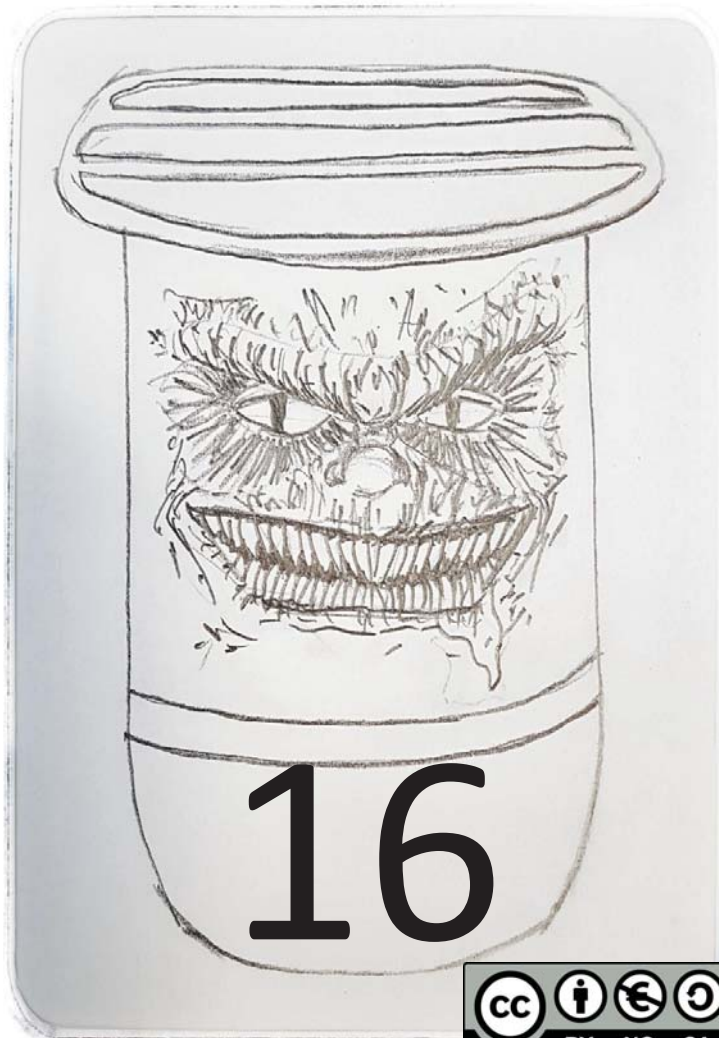
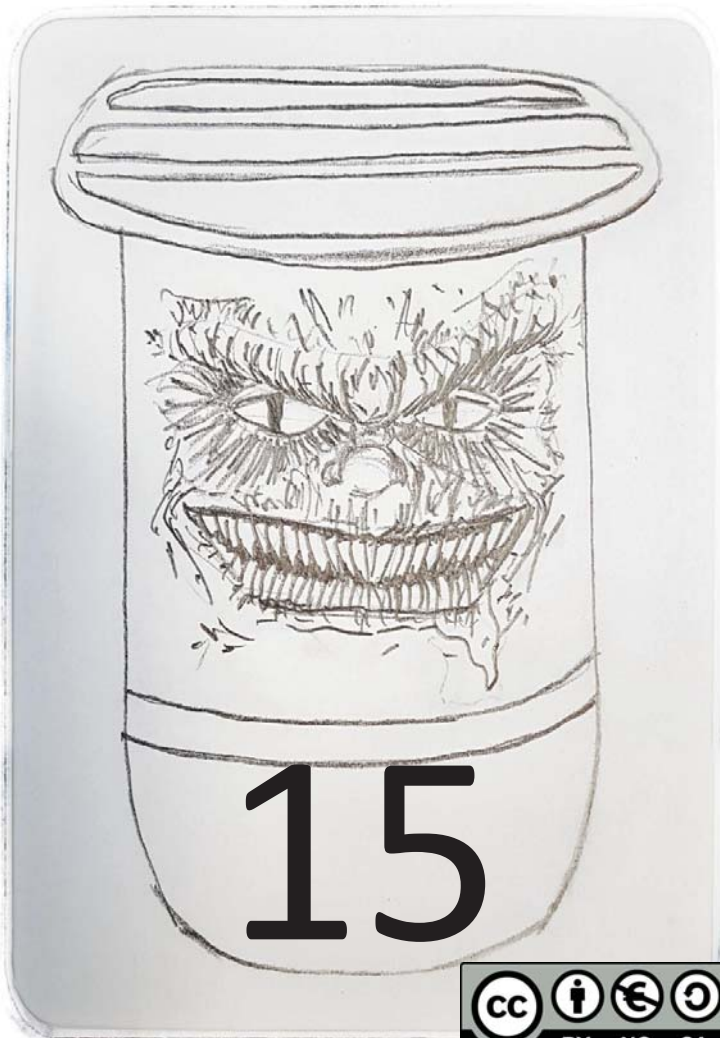
11

4—7

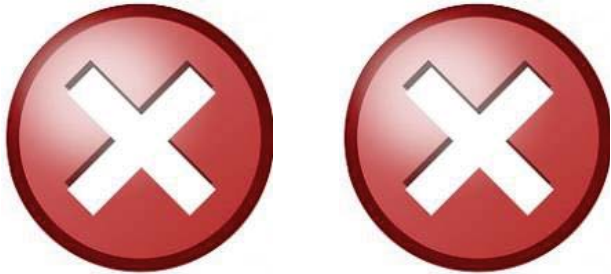


NO, the chuck key doesn't open the drawer...

The drawer contains: impellers; a key; punchcards (for the last level of the game).



14



Hum... would you mind not flooding the lab!

16



It's the wrong key.



13



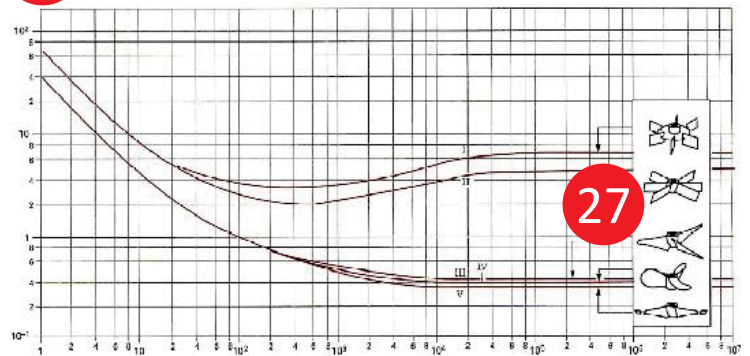
The electrical cabinet is locked.



15

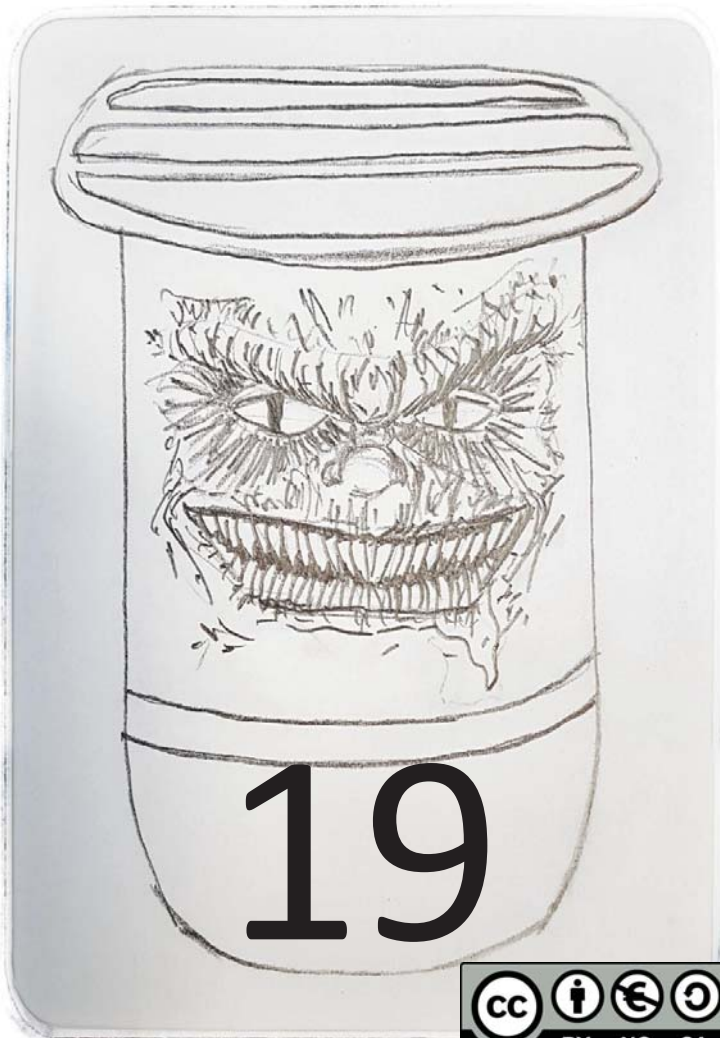
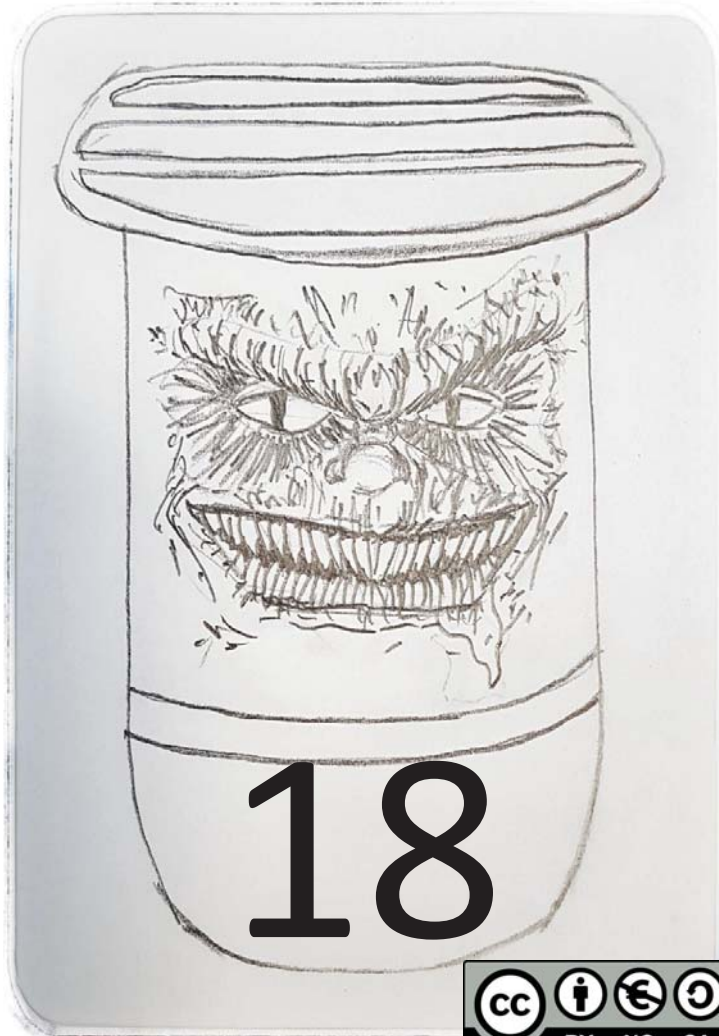


43



47

The intermediate aim of your manipulations will be to plot the power curves of some of the impellers...



18



This filling ratio doesn't correspond to the standard recommendations...

17



It's the wrong key.



20

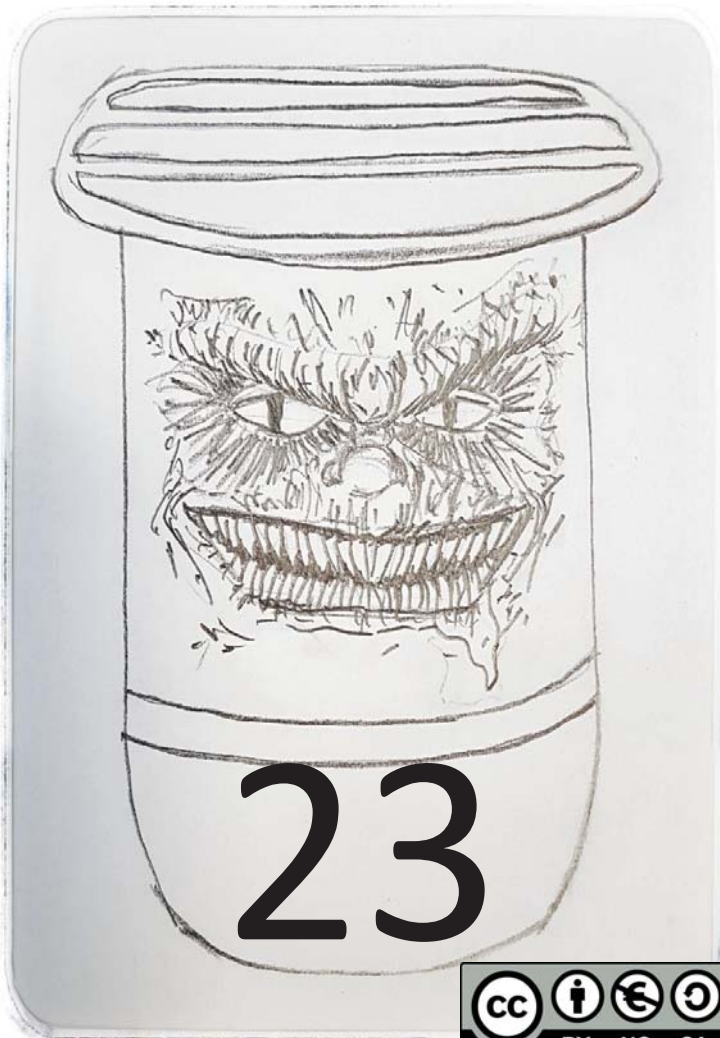
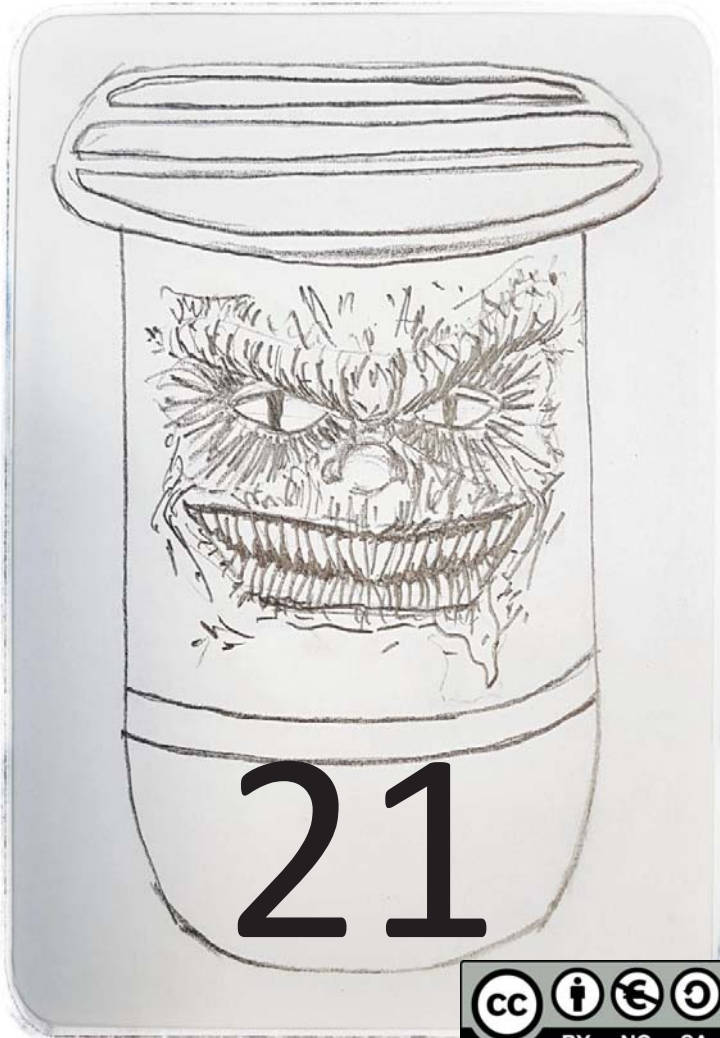


a tank

19



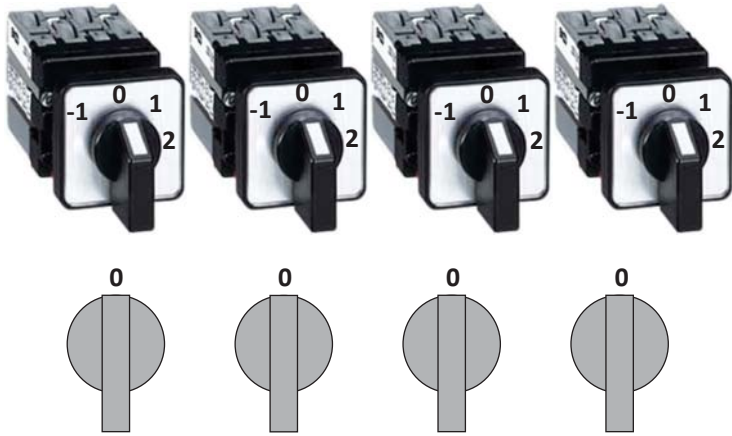
The tank is not filled enough.





22

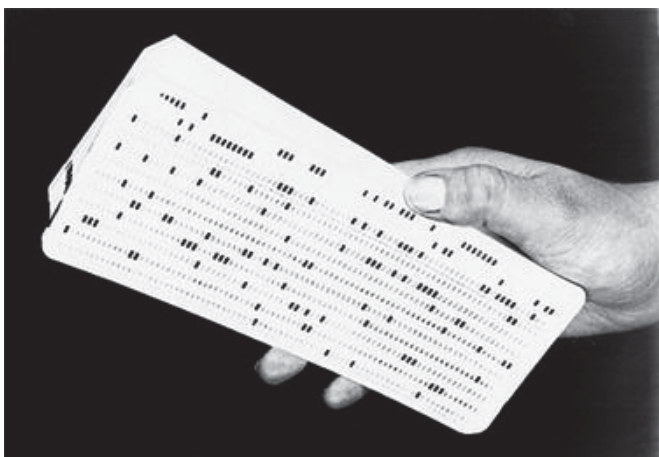
9 — 13 20



The electrical cabinet contains four 4-position switches. For the moment the position of all of them is zero. At level 2 of the game, you will have to choose the correct position to power an electrical outlet...



24



A set of punchcards required for level 3 of the game (Get them out of the drawer then discard this card 24.)

21



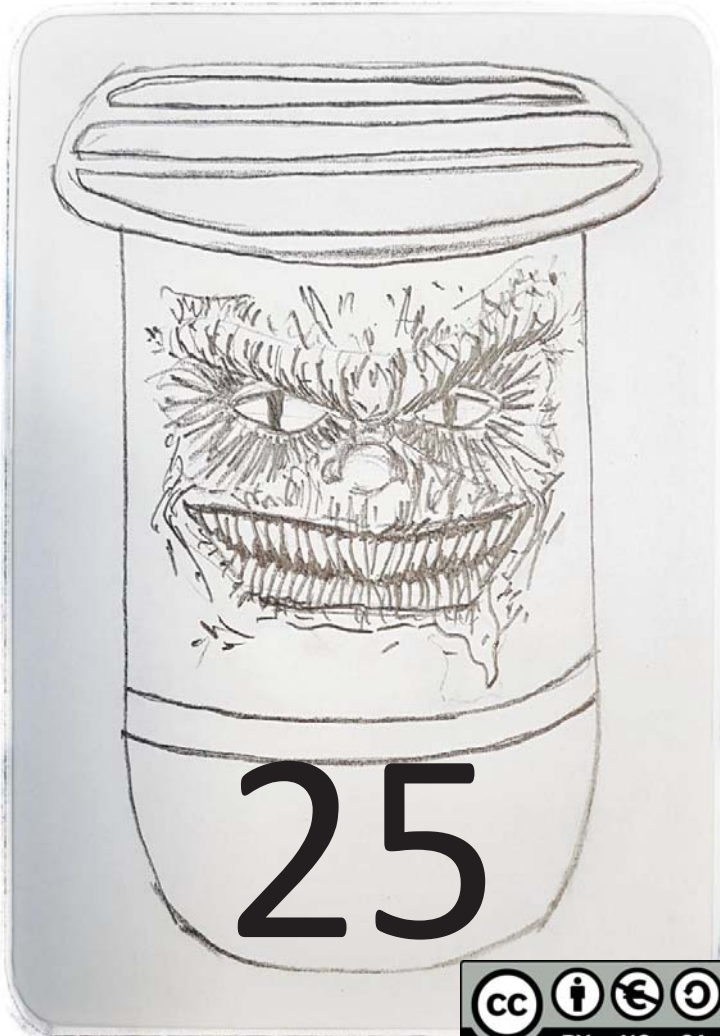
The tank measures:
20.5 cm internal diameter;
23 cm external diameter ;
29.5 cm depth in the center (the bottom of the tank is curved).



23



a stirring motor



26



25



Yes that's right, there's a second compartment in the toolbox.



This outlet is not yet powered.

28

The chuck key will indeed come in handy with the stirring motor, but to tighten what?

If you haven't already got what you need, you'll no doubt find it later on in the game (keep your eyes open, this object has a high number but it's well hidden...)



27

$$\text{Chuck Key} + \text{Chuck Key} + \text{Chuck Key} = 150$$

$$\text{Chuck Key} + \text{Propeller} + \text{Propeller} = 56$$

$$\text{Propeller} + \text{Chuck Key} + \text{Chuck Key} = 15$$

$$\text{Chuck Key} + \text{Propeller} \times \text{Chuck Key} = ??$$

a puzzle for Facebook wizards (and chemical engineering geniuses)



29

30



29

Which impellers to choose for the tank
AvAiLAbLe At the lAborAtory?

7 cm
impellers

37



5 cm impellers

50



impellers
of different diameters

32



31

8—23

•0,6 56

•1,2 58

•36 69

•60 60

•72 72

•120 70

•3600 71

•7200 74



The shaft is falling down
to the bottom of the glass tank,
it's dangerous!





34

increasing atomic number



dynamic viscosity

μ

to the power -1

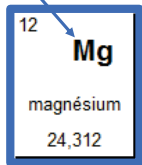
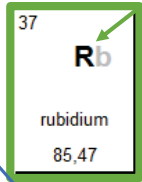


density

ρ

to the power 1

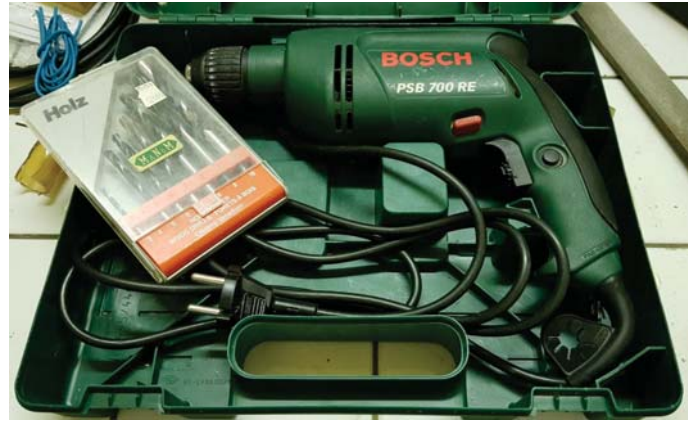
$$\nu = \frac{\mu}{\rho}$$



EXAMPLE with kinematic viscosity



33



a drill



36

5—31

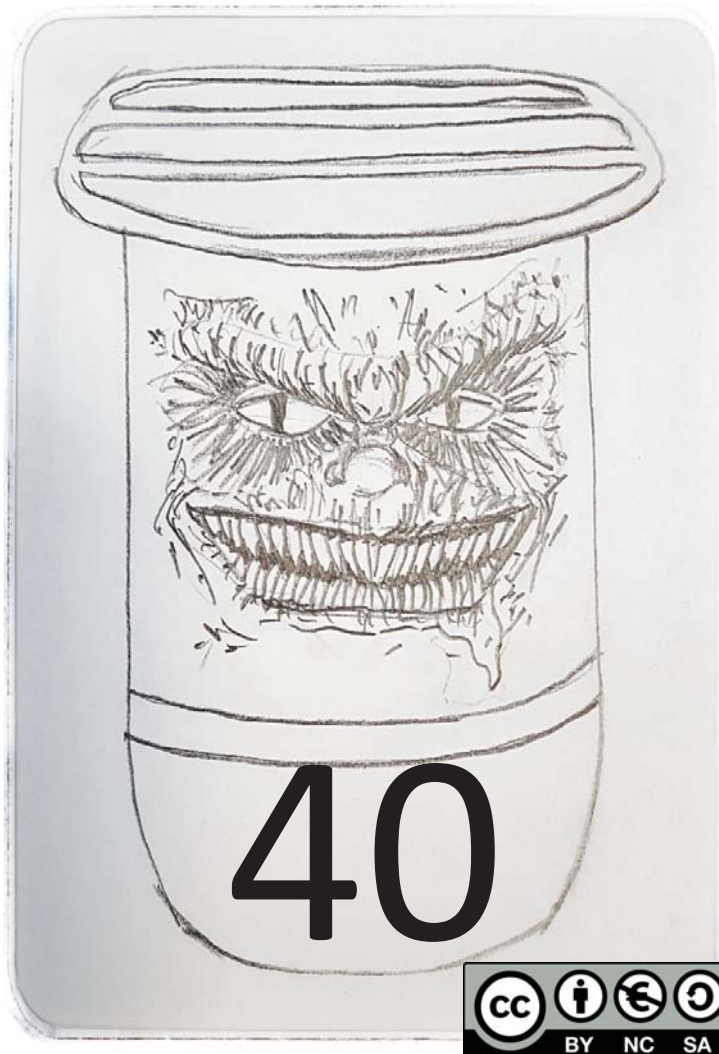
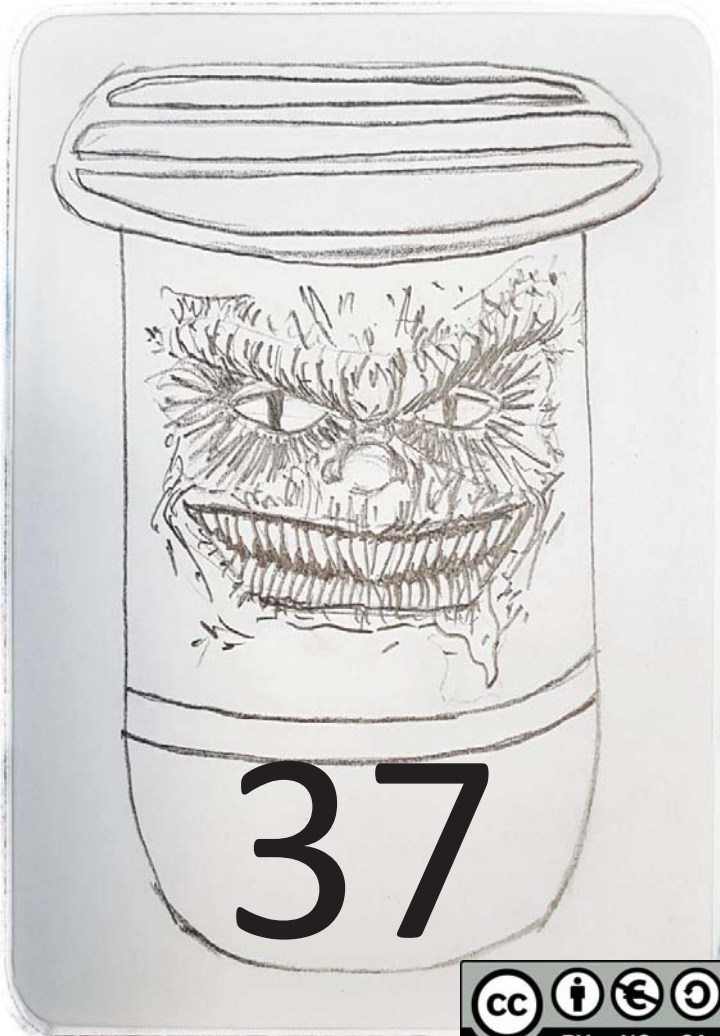


a stirring motor with its shaft fixed

35

The hexagonal keys will indeed come in handy with the impellers, but to tighten what?

If you haven't already got what you need, you'll no doubt find it later on in the game (keep your eyes open, this object has a high number but it's well hidden...)



33

38



30

37



mounted drill

suitable impellers for the tank

40

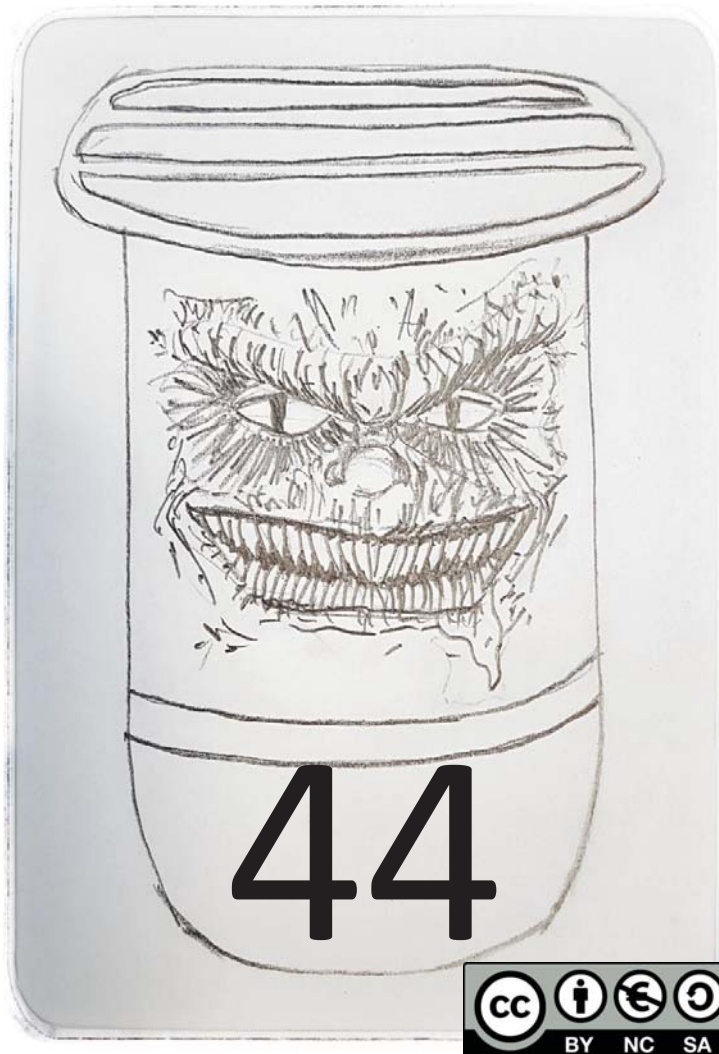
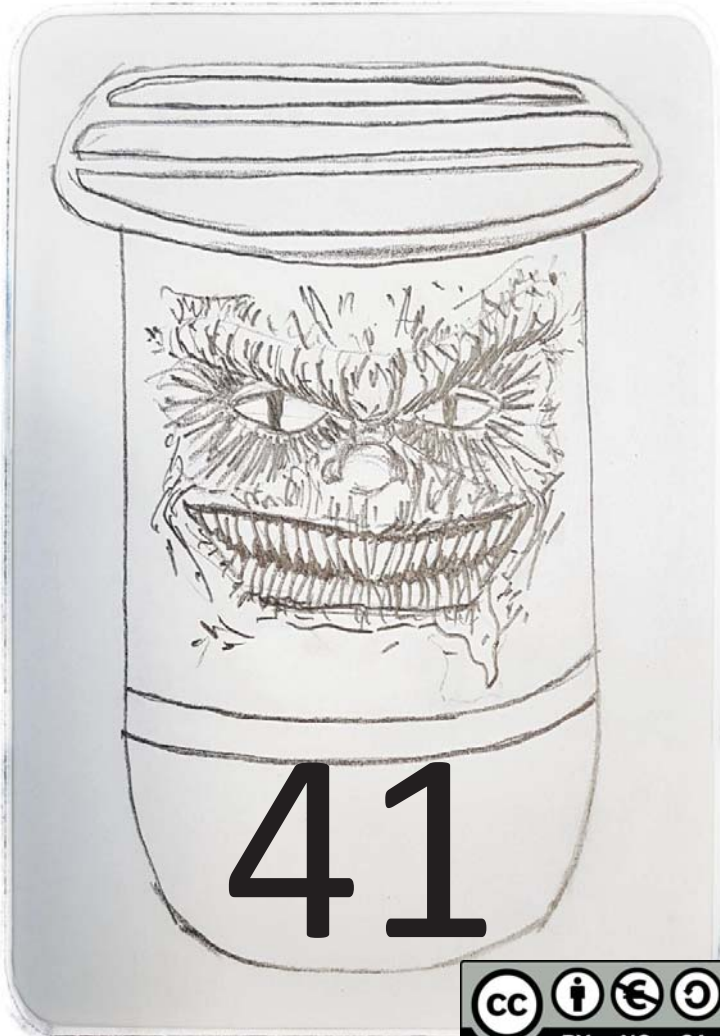
~~22 34 47 62~~

39



Your Reynolds number isn't dimensionless!

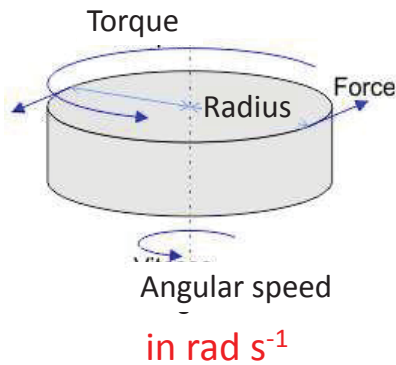
The power is back on again at last!





42

A usefull information for the last level of the game:



Torque is the moment of a rotating force, i.e. the ratio between power and angular speed.



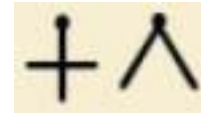
Your Reynolds number isn't dimensionless!



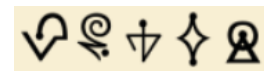
44

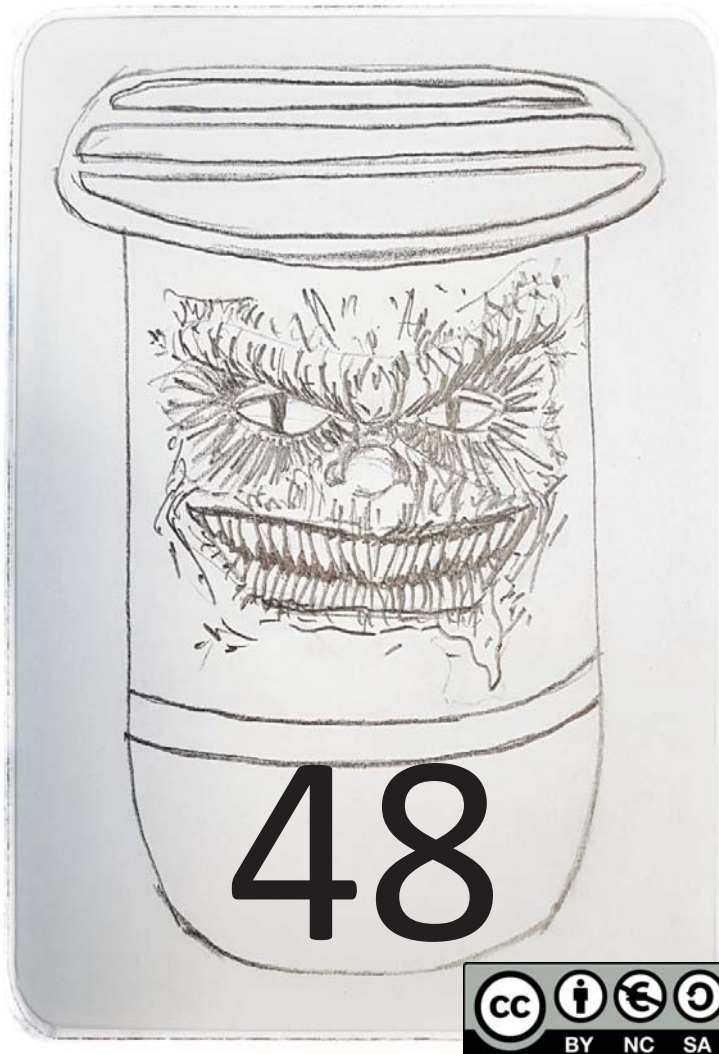
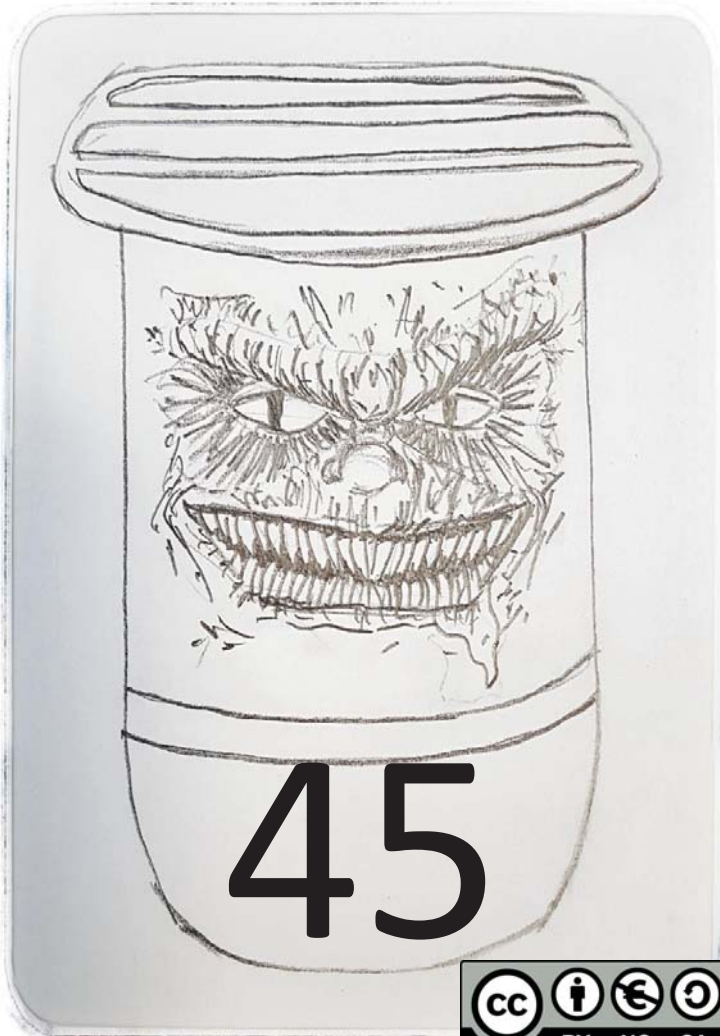


stirring motor on



A mystery that you'll have to solve for the third and last level of the game...







46

The numerical values are unimportant but note down carefully the units of the magnitudes displayed by the stirring motor!

45

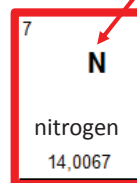


It's strictly forbidden to drill a hole in the desk or the drawer!

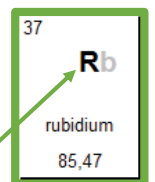
48



47



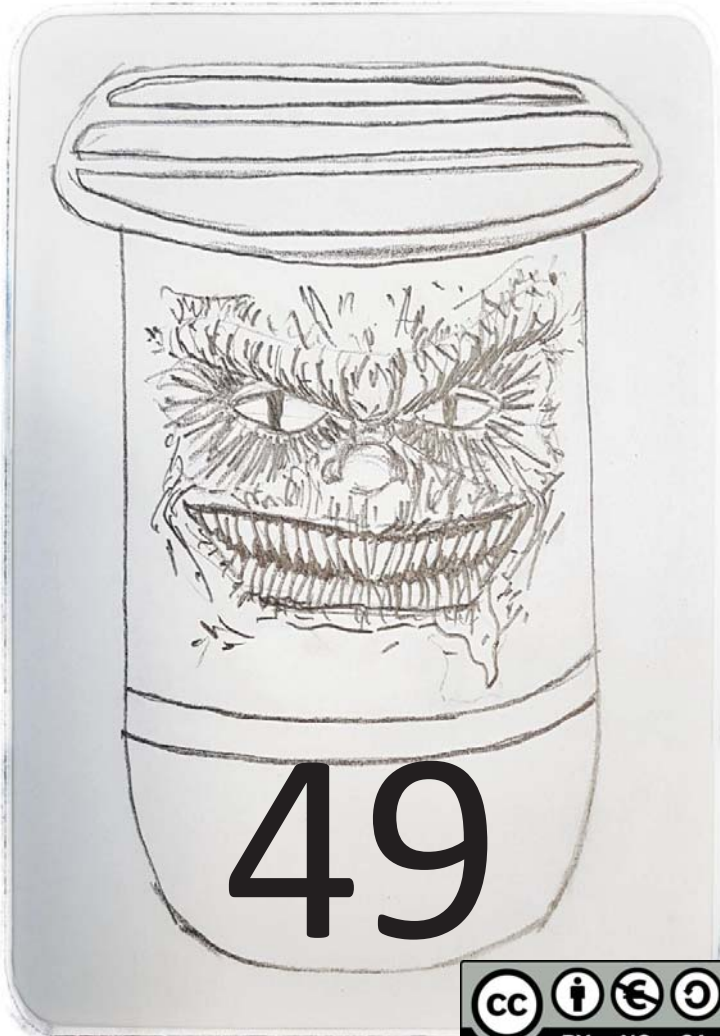
stirring frequency in s^{-1}



r ($\equiv \rho$ in Greek) in $kg\ m^{-3}$

NOT for a standard tank.

There are some elements missing in order to reconstruct the Reynolds number in a stirred vessel...



50



These impellers are too small for a standard tank of this size.

49

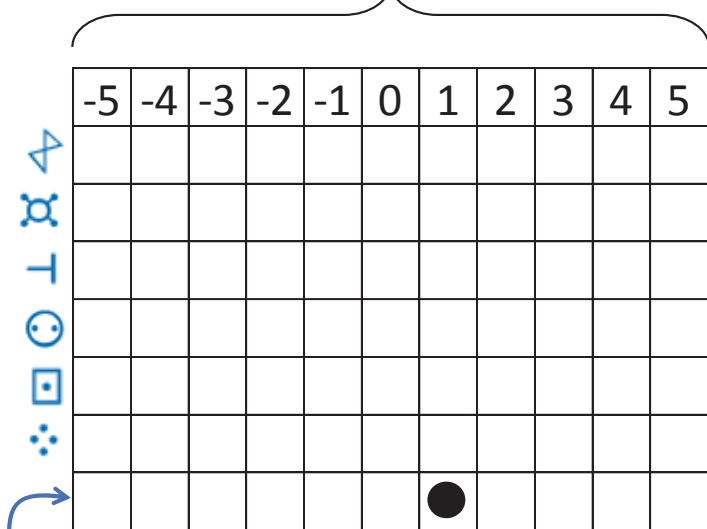


NOT for a standard tank.



52

power of each magnitude

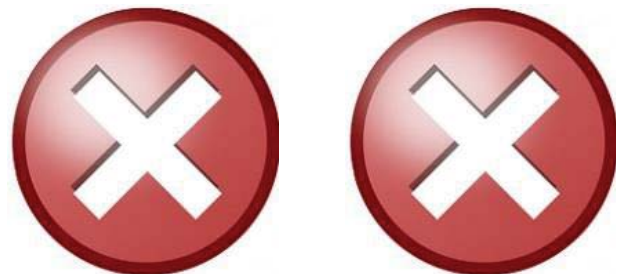


numerical value to be chosen on card

32

calculation of the power number

51



It's dangerous to break the electrical cabinet open with a drill!



54



NOT for a standard tank.

53



NOT for a standard tank.

56



Do not forget the powers.

~~1 11 21 33 81~~ 55

WELL DONE! you've reached level 1: the tank is ready.



After this "search" level, you can go on to the higher levels where the problems to be solved are more "scientific"... fewer cards, but more "brain juice"!

15



58



Do not forget the powers.

57



Put your glasses on!
there aren't only + signs.

60

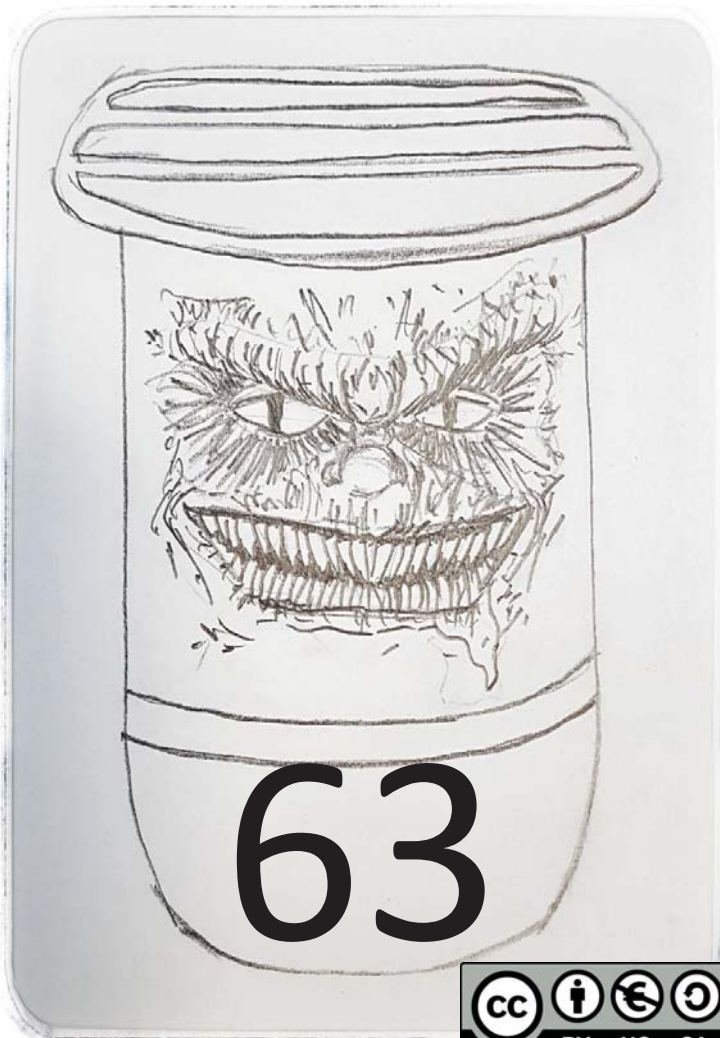


It's not so easy!

59



Put your glasses on!
there aren't only + signs.





62

27



61

increasing atomic number

→

	76
	39
	40
	41

What's the correct setting?

If you don't know what the torque unit is, consult the CONCENTRX:



You'll need it for the third and last level of the game.



64

25—39

63



WELL DONE! you've reached level 2: your formula of the Reynolds number is correct.

Carry on...

44

It's not the right punchcard. Viscosity doesn't enter into the power number.



66

~~15 42 61~~

65

punch
cards



This is not
the proper punchcards.



When you've found it,
add 10 to the card
corresponding to the
correct numerical value...

68

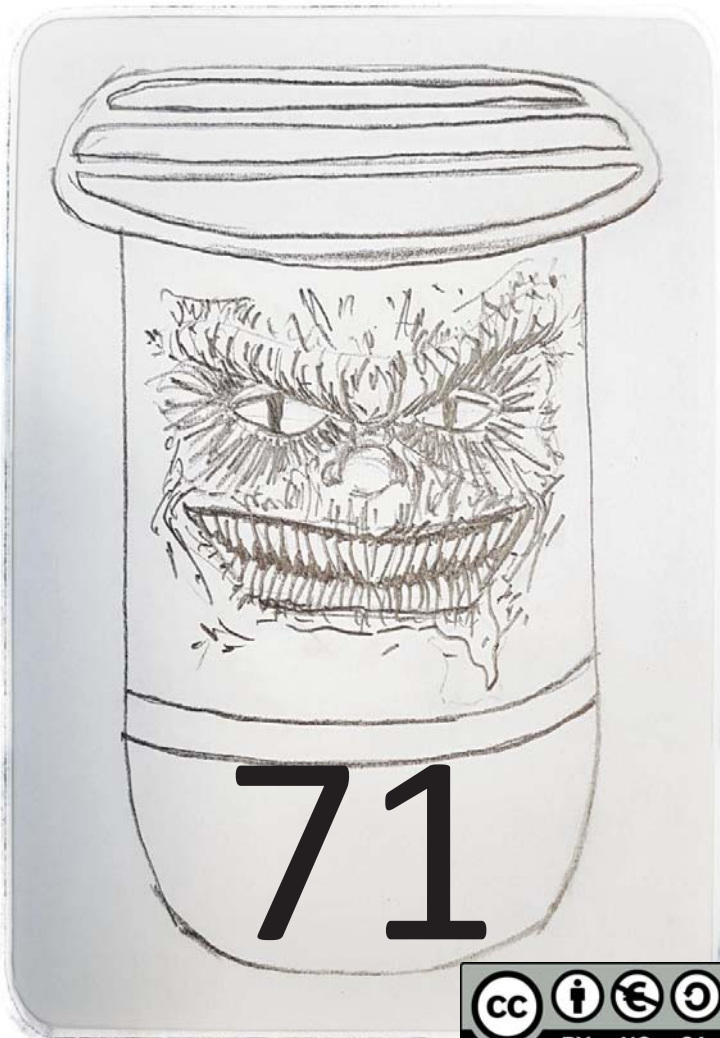
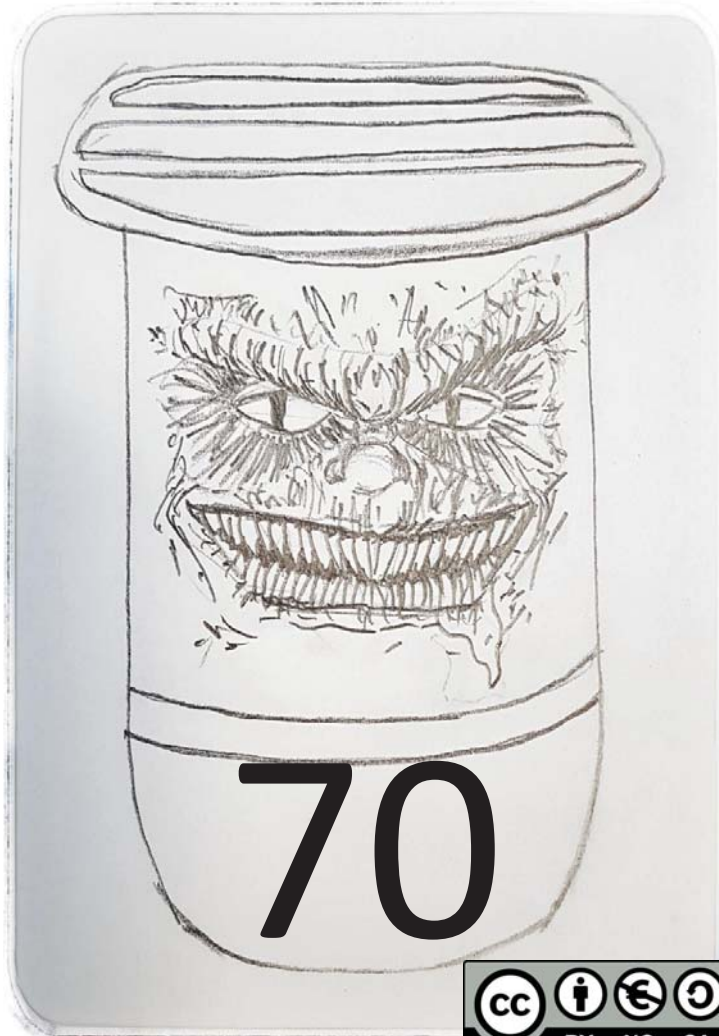
67



Take a close look
at the Rushton turbines...



This is not
the proper punchcards.



70



69



To get an angular speed from a frequency, what must you do?

multiply?

divide?

by...

There are some missing!

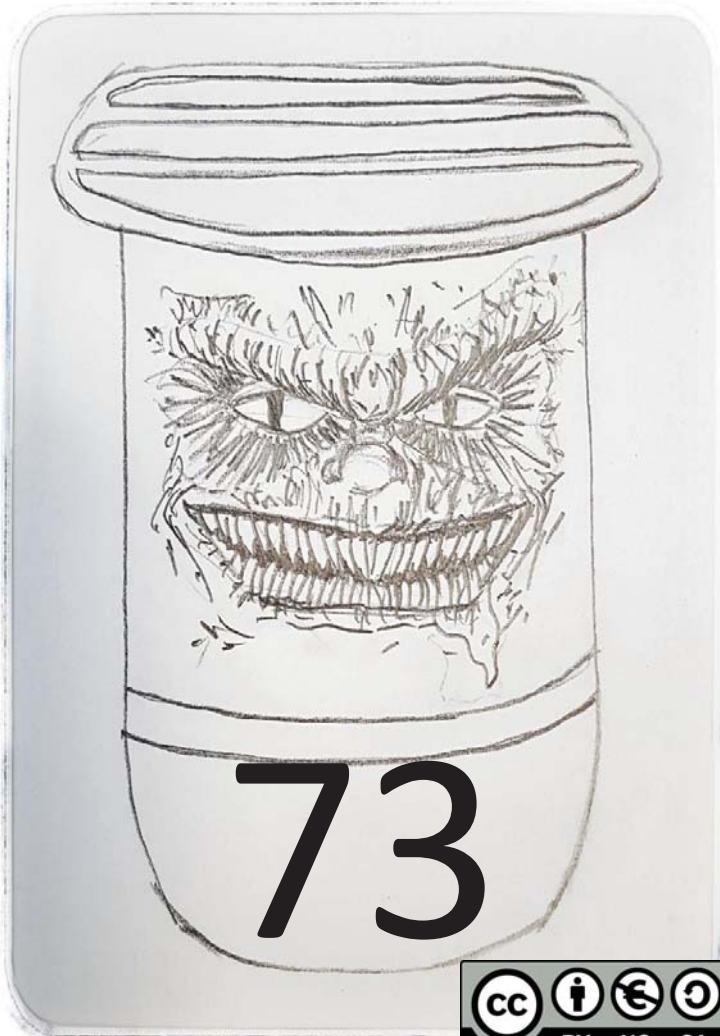
72

71



72+10
(as mentioned on card 65)

There are some missing!



74



Almost there...

Your Reynolds number isn't dimensionless!



73

~~36~~—~~37~~



The impellers need fixing on the shaft otherwise they'll fall off!

76



75



Mounting the impellers on the drill, why not? but it will be difficult then to determine the speed of rotation and the torque!



6 — 73

79



43

77



The power number (a dimensionless number) is defined by:

Other cards will help you to elucidate this power...

$$N_p = \frac{\text{power}}{\rho \cdot N^3 \cdot d_A^5}$$

in kg m⁻³ see the unit displayed on the motor in m



The impeller is properly mounted on the shaft.

82



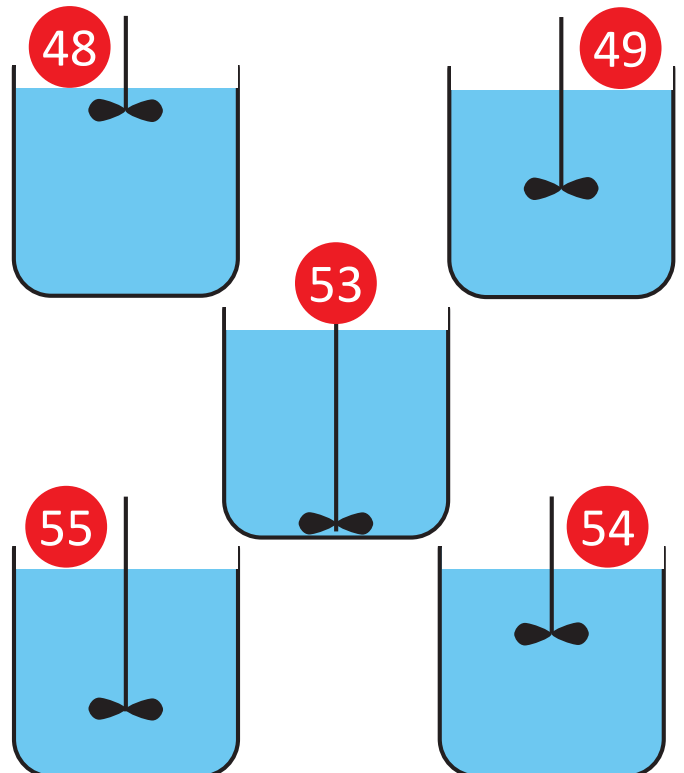
WELL DONE! you've reached level 3, the last level of the game: your formula for the power number is correct. **Don't forget to write it down: you will need it to exploit your measurement data.**



The game master gives you the miracle substance that precipitates the rat droppings and purifies the yoghurts. You will now be able to carry out your experiment in the lab. The factory manager will come and check the suspension before his press conference...

81

2 — 79



What's the correct setup?



zero



A



C



E



hidden object A

At some point or another it will be necessary to plug the stirring motor into the mains! Can't you see a plug that is numbered?...



hidden object E

Have you looked carefully at the electrical hazard sign?...



hidden object « zero »

Don't you think the handle of the fireproof door right at the end is a bit strange?...



hidden object C

A new casing has been installed between the two doors. But it hasn't been repainted yet: if you look more closely, can't you find another card?...





E



3



23



44



hidden object 3

As well as the numbers in red, can't you see another number in this toolbox?



hidden object E

Isn't there something sticking out of his overall pocket?...



hidden object 44

The orange reference on the motor looks "Photoshop-made"! ...

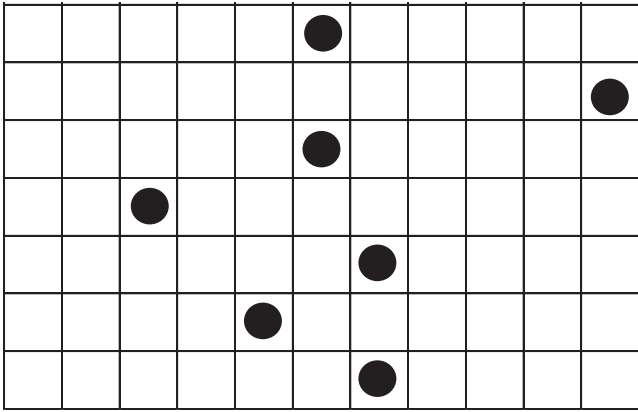


hidden object 23

That's a very unusual way to wind a cable! And what if it was the path to a new card?...



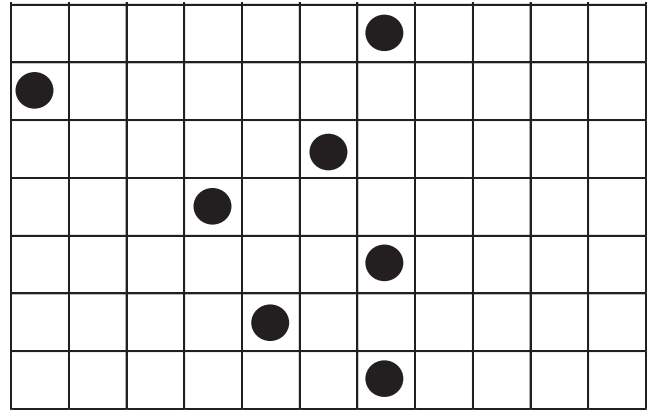
This punchcard should be superimposed on another card...



If you think you've made the correct superposition, turn the card over: **63**



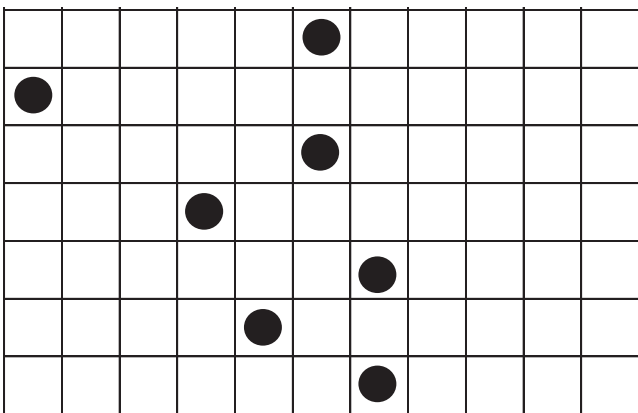
This punchcard should be superimposed on another card...



If you think you've made the correct superposition, turn the card over: **65**



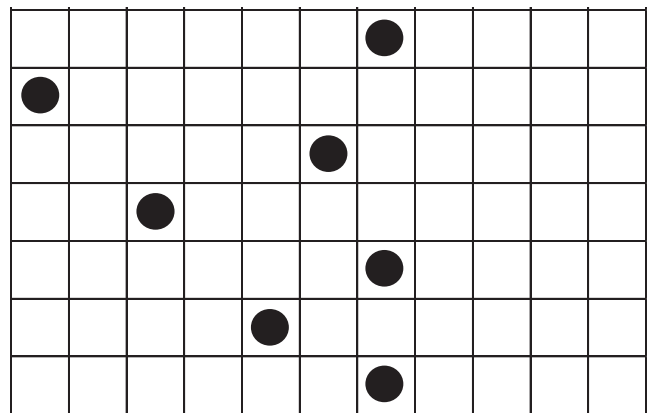
This punchcard should be superimposed on another card...



If you think you've made the correct superposition, turn the card over: **66**



This punchcard should be superimposed on another card...





If you think you've made the correct superposition, turn the card over: **67**



Solution to the game #CarnivorousYoghurts


Lilian BEZARD, Marie DEBACQ, Astrid ROSSO (Cnam) - 2019


Level 2 cards bear the symbol  ; level 3 cards have the symbol .

Level 1:

By turning over the card marked zero, you can find card E, but also card C (a hidden letter).

On **card E**, one finds the number 7, as well as 4 and 13 (hidden numbers).

The key on card 4 opens the drawer on card 7; there, you then find (card $4+7=11$): the key on card 9 (which opens the electrical cabinet of card 13: $9+13=22$, which will be used at level 2, given the symbol ); the punch cards of card 24

(which will be used for level 3, given the symbol ); the impellers of card 29.

Card C gives card A (white paint on the wall) and card F (sticker on the door). In the workshop on card F, one finds: a toolbox (card 3) and a drill equipped with drill bits (card 33). On opening the toolbox, one finds: a chuck key (card 5); a set of hex wrenches (card 6); the bottom compartment of the toolbox (number 26 hidden on the flat wrench). In this compartment there is a steel rule (card 1).

Combining the impellers on card 29 and the steel rule on card 1, one finds card $29+1=30$ which gives the dimensions of the available impellers.

Card A corresponds to the laboratory, where one finds: the stirred tank (card 20); a faucet (card 10); a power socket (hidden number 25). Combining card 20 (the tank) and the steel rule on card 1, one finds card $20+1=21$, which gives the dimensions of the tank and allows one to choose between the two sizes of impellers available: the correct size is $20.5/3 \approx 7$ cm (card 37).

Card 10 requires choosing the correct fill level of the tank (in accordance with standard recommendations), that is to say card 2. Card 2 combines with card 21 to give card $21+2=23$, the stirring motor. The strange winding of the electrical cable of the motor on this card 23 gives access to card 8: the impeller shaft. Combining the shaft with the motor gives card $23+8=31$ for which a tool is missing. This tool is the chuck key found earlier (card 5); combining cards 31 and 5 gives card $31+5=36$ with the shaft attached to the motor. The impellers on card 37 combine with card 36: $36+37=73$, but again, the tool that fixes the impellers on the shaft is missing: this tool is the hex wrenches on card 6. The card $73+6=79$ corresponds to the impellers fixed on the shaft, which is in turn mounted on the motor. This can be combined with the filled tank of card 2 in order to obtain card $79+2=81$. On this card, the correct position of the impeller has to be chosen: it is one-third the height of the liquid, i.e. card 55. This awards the 10 points of level 1.


Wrong associations:

- ✓ $5+7=12$: the chuck key doesn't open the drawer 7
- ✓ $9+7=16$: wrench 9 doesn't open the drawer 7
- ✓ $4+13=17$: wrench 4 doesn't open the electrical cabinet 13
- ✓ $5+23=28$: confirms the advantage of combining the chuck key 5 with the stirring motor, but it is not enough
- ✓ $6+29=35$: confirms the advantage of combining the hex wrench 6 with the impellers 29, but it is not enough
- ✓ $5+33=38$: a drill bit is mounted on the drill (so far, so good)
- ✓ $7+38=45$: it is forbidden to force the drawer open using the drill!
- ✓ $13+38=51$: it is not only forbidden but even dangerous to force the lock of an electrical cabinet with a drill!!

Level 2:

Card 55 (the last one of Level 1) gives access to card 15, which in turn gives the cards 27, 43 and 47.

The puzzle on card 27 gives access to card 62 (the anchor is worth 20; the marine propeller 3; the Rushton turbine with 6 blades, 6; the final sum is therefore $50 + 3 \times 4$ (because the Rushton turbine in the last line has only 4 blades; and note the x sign, whereas on the other lines only the + sign was used) $\Rightarrow 62$. Card 47 begins to reveal the principle of the puzzle at level 2.

Card 43 will come in useful at level 3 (symbol ).



In the lab notebook, on page 3, there is a **polychromacryptograph** that can be decoded with the red folder and that gives the formula of the Reynolds number for a stirred vessel: $Re = \frac{\rho \cdot N \cdot d_A^2}{\mu}$, where ρ is the density, N the stirring frequency, d_A the diameter of the impeller, and μ the dynamic viscosity. The message is as follows:

In a stirred vessel, the Reynolds number is the product of the density of the medium multiplied by the stirring frequency and the diameter squared of the impeller, divided by the dynamic viscosity of the medium.

In the **lab notebook**, on page 5, you have to calculate -in dm- the volume of the industrial tank required to deal with the 250 000 contaminated yoghurts, each 125 mL, i.e. 31.25 m³. A standard tank should be filled up to a height equal to the diameter of the tank; its volume is therefore $\pi \cdot D^3 / 4$. The 31.25 m³ can therefore be contained in a tank with a diameter of 3.414 m, or, rounded off, 34 dm, which gives card 34.

The puzzle at level 2 therefore comprises the cards 22 (found at level 1), 34, 47 and 62.

- Card 47 shows that the elements in the periodic table are associated to the quantities of the Reynolds number: nitrogen (**N** atomic number 7) for the stirring frequency N ; rubidium (**Rb** atomic number 37) for the density (in Greek ρ corresponds to R in Latin, as mentioned on page 7 in the lab notebook); magnesium (**Mg** atomic number 12) for the dynamic viscosity [visible on card 34; in Greek μ corresponds to M in Latin]; the element representing the diameter is therefore missing. The usual symbol for diameter is d_A ; on page 2 in the lab notebook, one finds the periodic table: it can be observed that the element chosen to represent a physical quantity is the first (the smallest atomic number) in which the first letter of the symbol is the same as the physical quantity. For d_A it is therefore dysprosium (**Dy** atomic number 66) that should be selected [in fact, it's the only element in which the symbol begins with the letter D].
- Card 34 suggests how to associate these quantities in order to reconstruct the Reynolds number, and also suggests the link with the switches (card 22 shows how to position the switches to obtain the values -1; 0; 1 et 2). The quantities must therefore be classified by increasing order of atomic number and a power must be associated with them; this power needs to be set on each switch. Thus, the physical quantities are classified in the following order: stirring frequency **N** (atomic number 7) to the power +1 (switch oriented to the right); dynamic viscosity $\mu \leftrightarrow$ **Mg** (atomic number 12) to the power -1 (switch oriented to the left); density $\rho \leftrightarrow$ **Rb** (atomic number 37) to the power +1 (switch oriented to the right); impeller diameter $d_A \leftrightarrow$ **Dy** (atomic number 66) to the power +2 (switch oriented to the right, one notch further).
- Once these powers have been set on the switches on card 62, one can see that the settings correspond to card 39: on 39 the power has been restored.

This card is then combined with the power outlet on card 25: 39+25=64. This awards the 20 points of level 2.

Level 3:

Card 64 gives card 44, which gives the cards 46 and 61 + 52 (hidden number).

On the last page of the **lab notebook**, there is the poster of the movie “H2G2 : The Hitchhiker's Guide to the Galaxy”, based on the book by Douglas ADAMS, in which the number 42 (that can be seen on the movie poster) is an important symbol: it is the answer to the Ultimate Question of Life, the Universe, and Everything! In other words, the player can take card 42, which will provide assistance at level 3.

Card 15, which was found just after completing level 1, gave card 43 for this final level of the game. Card 43 is partly written in alien alphabet (which can be decoded thanks to page 6 in the lab notebook): once decoded, one can read “power number” and the number “77”: the player can therefore take card 77.

Card 52 gives access to card 32.

Card 61 recommends using the **concentrx**. By turning the disks of the concentrx, this reveals information that allow one to find the unit of power:

$$\text{power} = \text{energy} / \text{time}$$

Work is a form of energy.

The work of a force is the product of the norm of the force multiplied by the displacement it induces.

$$\text{So power } [W] = \frac{\text{energy } [J]}{\text{time } [s]}; \text{energy} \leftrightarrow \text{work } [J] = \text{force } [N] \cdot \text{displacement } [m]$$







The puzzle at level 3 includes, therefore, the cards 32, 42, 46, 52, 77, as well as the punch cards found in the desk drawer at the beginning of the game and the clues provided by the concentrx.

- Once the correct expression has been found for the power number with the “correct” units, the player then needs to choose a numerical value on card 32.
- Card 77 gives the expression for the power number and hints at the problem of the units of the quantities.

- Card 46 stresses the importance of the units indicated on the stirring motor (card 44): the stirring frequency N in rpm (revolutions per minute) and the torque in N cm.
- Card 42 states that the torque is the ratio between power and angular momentum; the latter is expressed in rad s^{-1} . There is therefore a factor of 2π between this angular momentum and the stirring frequency (if the latter is in s^{-1} ; but according to card 44 it is in rpm!). The power can then be related to the torque by the relation: $power [W] = 2\pi \cdot N [s^{-1}] \cdot torque [N m] \equiv 2\pi \cdot \frac{N [rpm]}{60} \cdot \frac{torque [N cm]}{100}$ (because we saw on card 44 that the torque is displayed in N cm on the motor).
- Card 52 shows a table on which one guesses that the punch cards should be superimposed (Careful! there is an offset between the tables on card 52 and the punch cards, so they need to be superimposed properly in order to solve this enigma): the lines correspond to the quantities to be assembled in order to find the power number (in alien alphabet; see the correspondences on page 6 of the lab notebook); the columns correspond to the powers of the different quantities.

In order to find the power number and obtain the correct value of the numerical factor (which will be to the power +1 in accordance with what is shown on card 52), one must write: $N_p = \frac{power}{\rho \cdot N^3 \cdot d_A^5}$ (cf. card 77) then replace the power by $2\pi \cdot N \cdot couple$ (thanks to the indications given on card 42 and given that the angular momentum is equal to 2π times the rotation frequency). One then needs to include the units and, if need be, the conversion factors:

$$N_p [-] = \frac{2\pi \cdot \cancel{N} \cdot \frac{torque [N cm]}{100}}{\rho [kg m^{-3}] \cdot \left(\frac{N [rpm]}{60}\right)^{\cancel{3}^2} \cdot (d_A [m])^5}$$

The torque () is therefore to the power +1; the impeller diameter () is to the power -5; the viscosity () is not part of the power number, so it is to the power zero; the stirring frequency () is to the power -2; the number π () which is needed for the conversion angular momentum \leftrightarrow stirring frequency is to the power +1; the density () is to the power -1. The correct punch card is therefore the one that leads to card 65. The latter card indicates that, once the correct choice of numerical value has been made on card 32, it is necessary to add 10 to the number of the correct card. The correct numerical factor is equal to $72 \left(\frac{2 \cdot (60)^2}{100}\right)$. On adding 10 to 72, one gets card 82, which awards the 30 points of level 3. Game over.

If you turn over the remaining cards, you should find that they correspond to all the errors, or in some cases to the red herrings (cards 28, 35 and 38).